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ABSTRACT

This booklet is made available by the National Science Teachers Association to provide district safety officers, school principals, science department heads, and secondary school science teachers with information on safety in schools, especially in science classrooms. The range of information includes Occupational Safety and Health Administration, first aid, general and specific instructions to teachers and students in biology, physics, chemistry, and life/physical science classes, and safe practices to follow for extra curricular activities. The publication is a compilation of recommended practices in the area of science taken from many sources throughout academia and industry. The booklet includes a recommended standard student accident report format and a bibliography for further reference. (GA)

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SAFETY

Safety in the Secondary Science Classroom

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Introduction

This publication has been made available by the National Science Teachers Association to provide district safety officers, school principals, science department chairpersons, and especially secondary school science teachers with a source they may refer to for suggested practices to insure a safe environment in all science related activities.

Safety in the Secondary Science Classroom is an extensive publication providing information about the Occupational Safety and Health Administration, first aid, general and specific instruction to teachers and students in biology, chemistry, physics, and life/physical science classes, and safe practices to follow for extra curricular activities. We encourage all teachers to become familiar with all sections of this manual, as many activities involve equipment and procedures from the other science disciplines.

Science is a discipline and to be meaningful to the secondary science student, there must be activities complementing the cognitive knowledge acquired. Activities include everything from taking field trips, observing demonstrations, conducting laboratory investigations, to working independently on a science project. These activities, conducted safely, enhance the goals of science education that include attaining manipulative and communication skills, rational thinking processes, and scientific attitudes. The science laboratory is where most of these activities will be conducted by the student. Therefore, the emphasis of this publication is on safety in the science classroom.

A major consideration for anyone offering a science program in the secondary school is safety. When teachers are aware of potential hazards and have given their students instructions and skills to avoid needless accidents, personal injury and equipment damage can be kept to a minimum.

This publication is a compilation of recommended practices in the area of science taken from many recognized sources throughout academia and industry. A separate page of acknowledgements has been prepared to indicate where much of this material was obtained.

No publication could be prepared to list safe practices for science in every situation. Proper planning, prudent foresight, and care must be continuously exercised by the classroom teacher and students to help them cope with situations as they arise. It is the purpose of this publication to recommend safeguards so as to offer safe science instruction. The suggestions and precautions indicated are designed to facilitate rather than to inhibit good science activities.

The information contained herein is correct to the best of our knowledge. The National Science Teachers Association is not attempting to establish universal laws, regulations or rules. The information should not be read as legal requirements, but as suggestions and recommendations for the establishment of a safety base upon which to build. Safety suggestions made should be considered in conjunction with appropriate codes, standards, regulations, and federal, state and local requirements that may prevail. Of course, knowledge of the science course to be taught, experience in conducting all the activities, and good common sense on the part of the teacher will avoid most situations where harm may come to the students.

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The Safety Program

School Safety Responsibilities

The district safety officer, school principal, and science department chairperson share the responsibility for insuring that adequate precautions are taken to provide for a safe and healthful working environment for the science teacher and the students enrolled in science classes.

A safe working environment often begins with the physical construction of the building site or the remodeling that may have been done to existing science facilities. The following are suggestions to follow in order to provide proper physical facilities for a safe science laboratory.

A. Safety Officer/Principal Responsibilities

1. Provide adequate lighting and heating. For reasons of work efficiency and safety, laboratories should have lighting which takes into account the variances in working conditions common to science laboratories. While 100 foot-candles of diffused light may be adequate for most situations, certain aspects of close work may require more. Light switches and thermostats should be in proper working condition.
2. Work space should be adequate to permit the proper conduct of experiments. How much space this is depends upon such variables as the nature of the course, whether or not the laboratory is used also for classroom discussion, and how much the science program emphasizes individualized instruction. As a reasonable rule of thumb, NSTA recommends that there be a minimum of 45 square feet (5.5 square meters) of space per student if the room is a combination classroom-laboratory, and a minimum of 35 square feet (4 square meters) per student if the space is strictly for laboratory. (*Conditions for Good Science Teaching in Secondary Schools,* NSTA, 1970).
3. Every science laboratory must have two unobstructed exits remote from each other. These should open into a main passage or to the outside of the building, not into a supply room, office, or other intermediary space. In order to insure quick egress it should not be possible to lock the doors from the inside.
4. Laboratory table tops should be constructed of

non-combustible material. Wood furnishings should be treated to reduce combustibility. All furnishings should be sturdy and have rounded corners and edges.

5. Master shut-offs should be provided for gas, water, electricity and any other services that might involve danger should an accident occur. Master shut-offs should be well marked and easily accessible.
6. Electrical outlets must be grounded according to local or State electrical code.
7. A properly sized fume hood and/or exhaust fans should be provided for removal of toxic and/or noxious fumes.
8. Adequate space for storage of chemicals and supplies should be provided. (See "Storage" page 37.)
9. Fire extinguishers based on the type of fire anticipated should be provided and routinely inspected. (See "Fire Prevention and Control" page 19.)
10. A safety shower in areas where hazardous chemicals are used should be provided and properly maintained. Water flow should be sufficient to dilute material to a safe level in fifteen seconds.
11. A face and eye shower should be available in all laboratories.
12. Prompt action should be taken to correct any unsafe or hazardous conditions or practices.
13. All physical facilities should be inspected regularly for unsafe conditions or safety violations.

B. Department Chairperson Responsibilities

1. Periodically, but not less than quarterly, through departmental conferences starting at the beginning of each term, make all science teachers and laboratory assistants aware of the hazards in science instruction and stress the seriousness of accidents caused by carelessness, unsafe practices, and the use of improper equipment.
2. Notify the principal in writing (maintaining a copy for your file) of any hazards such as:
   a. Defective gas connections and fixtures, electrical outlets, apparatus, and connections.
   b. Defective seats that may cause injury.
   c. Inadequate or defective storage cabinets.
   d. Defective or lack of face and eye showers, fire blankets, fire extinguishers, fire pails, and sand.
3. Insure that a First Aid kit is in each science laboratory and preparation room and elsewhere as needed. One copy of the Red Cross book *Standard First Aid and Personal Safety*

should be kept with each First Aid kit. (See "First Aid" page 15.)

4. Inspect First Aid cabinets to insure that they are fully stocked and that fire extinguishers are operational at the beginning of each term.
5. Make certain that combustible and dangerous materials are kept securely locked in an approvide safety cabinet. Acids should be stored in approved cabinets or closets, off the floor and below one's height. Students should not have access to such cabinets, storerooms, or closets in stockrooms.
6. Inspect hardware and equipment and maintain records of the dates and findings of such inspections.
7. Instruct the laboratory assistant or teacher to rehearse the actual procedures of each laboratory experiment or demonstration prior to the class session to see that all materials and apparatus work properly and that safety precautions are adequate.
8. See that teachers remove or regroup accumulated materials that are safety or health hazards. This applies to preparation and storage rooms as well as to classrooms. Accumulations of glassware and chemicals on demonstrations tables, of exhibits or projects that overload shelves, or miscellaneous items stored on window sills are some examples of conditions that should be corrected.
9. Metal or earthware waste jars should be provided in every classroom and laboratory where science experiments are performed.
10. Teachers not qualified to teach science should not be assigned to science classes.

C. Science Teacher Responsibilities

Each science teacher should instruct their students in proper safety procedures, both in general, and in terms of the course they are taking. A set of safety rules should be available to students and be posted in several places around the science room. These rules should be discussed frequently with the students.

These rules might include many of the suggestions made in sections of this publication and certainly instructions regarding eye and face protection, fire hazards, the use of fire extinguishers and blankets, the proper use of fume hoods, the care and handling of laboratory animals, and the handling of radioactive materials.

The mere posing of safety guidelines and procedures has been held by the courts to be, in itself, insufficient instruction in providing proper safety procedures in the science classroom, but it should be done anyway. In order to demonstrate that reasonable care has been taken, the science teacher must remind the students of the hazards and proper safety procedures at the beginning of each class session where there may be an element of danger.

Sections of this publication have been prepared to serve as a guide for teachers for preparing safety instructions for students in biology/life science, chemistry, and physics/physical science. All or part of a specific section should be reviewed with the students prior to engaging in laboratory activities on a regular basis. A Student Safety Contract, suitable for duplication, is also available in the appendix and provides a focal point for students to discuss safety in the laboratory and follow proper safety procedures. All or any part of this publication may be duplicated by teachers for use in their classroom.

Suggestions for a Safe Science Program

Accidents do not just happen—they are caused. If the potential cause can be detected and eliminated, accidents will not occur. Accidents in the science classroom are often caused by the lack of a proper educational safety program, improper supervision of students (possibly aggravated by excessive class size), faulty laboratory techniques, and poor housekeeping programs.

Types of Accidents and Injuries

In teaching science, personnel may be involved in any of the three general classes of accidents.

1. **Burns.** Burns may be caused by fire, chemicals, hot vapors, electricity, etc. The seriousness of the burn will vary with the temperature, the concentration and type of chemical, degree of body exposure, part of the body involved, duration of exposure, and other factors.
2. **Injuries.** Injuries include those caused by explosions, electric shock, falling objects, broken glass, etc.
3. **Poisons.** Poisoning involves any toxic effect produced by inhalation of fumes, ingestion of chemicals, contact with certain plants, exposure to excess radioactivity, bites of animals, etc.

To avoid accidents and injuries in the science classroom, both teachers and students should heed the following safety suggestions.

The teachers should be aware that:

1. It is the initial responsibility of teachers to prevent accidents and assure that the laboratory is as safe as possible.
2. Laboratory safety should be taught continuously. Safety rules should be posted in a conspicuous place in the laboratory.
3. Teachers should demonstrate where possible and instruct students on necessary safety procedures immediately before beginning laboratory work.
4. Teachers are responsible for following prescribed accident procedures if an injury or accident occurs.
5. In case of an emergency, the prompt and calm handling of an emergency situation is imperative if panic is to be avoided.

6. Teachers should receive certification from the American National Red Cross in First Aid.
7. Teachers should notify those in authority of the existence or development of any hazard that comes to their attention.
8. When using flammable volatile liquids, such as alcohol, in a demonstration experiment, care must be taken that all ignition sources are removed from the classroom.
9. Demonstrations involving explosive mixtures must be so arranged as to shield both pupils and teachers from the results of the explosion. Even when there is no likelihood of an explosion, pupils should be asked to evacuate seats directly in front of the demonstration table whenever there is any possibility of injury to them by the spattering of a chemical, an overturned burner, inhalation of fumes, etc.
10. Class conditions for lighting, ventilation, heating, and orderliness should be controlled by the teacher.
11. Readily accessible spill packages for cleaning spills and metal containers for the disposal of broken glass should be available.
12. The floor should be kept free of equipment, refuse, and spilled materials. Good housekeeping is essential to proper safety.
13. Reagent shelves should be equipped with a ledge or restraining wire to prevent slipping or sliding of bottles or glassware.
14. Teachers should know the location of and how to shut off utilities. Label and/or color code all master shut-offs clearly.
15. Ventilation hood escape outlets and fans should be checked periodically to assure proper operation.
16. All poisons and dangerous reactants should be locked when not being used.
17. Teachers should know the location and proper operation of fire extinguishers.
18. Sand, fire blanket, vermiculite, bicarbonate of soda, etc., should be kept on hand for fires and absorption of spilled reactants.
19. Safety shower and eye and face shower should be checked daily.
20. A well-supplied First Aid kit should be provided. (See page 17 for suggested contents.) A chart showing proper treatment for specific injuries should be prominently posted.
21. Teachers should dispose of dangerous waste chemicals and materials as prescribed by appropriate standards and the laws for your community. Provide separate waste receptacles for broken glass and waste paper.
22. Laboratories and storage facilities should be locked at all times when not under direct super-

vision of responsible person.

23. You should have a thorough understanding of the potential hazards of all the materials, processes, and equipment that will be in the school laboratory.
24. Students should not have indiscriminate access to the laboratory stockroom and should never be permitted to study, work, or experiment without competent supervision in the laboratory.
25. All reagent bottles should be prominently and accurately labeled with labeling materials not affected by the reagent.
26. Teachers set an example for their students. Follow all safety regulations and constantly remind students of hazards.
27. Teachers should guard against poisoning by:
    a. Providing adequate ventilation for students working with volatile substances.
    b. Instructing about the avoidance of the ingestion of chemicals.
    c. Identifying plants and animals that may cause poisoning by contact or by a bite.
    d. Setting up safeguards against exposure to radioactive substances.
28. Make accident reports promptly, accurately, and complete. (See sample Accident Report Form, page 102.)

The student should be aware that:

1. All accidents should be reported to the teacher immediately, no matter how minor.

   Only those laboratory activities where instructions and permission have been given by the teacher should be performed.
3. Only materials and equipment authorized by your instructor should be used.
4. Written and verbal instructions should be followed carefully.
5. Chemical goggles should be used when working with dangerous chemicals, hot liquids or solids, radioactive materials, and other potential sources of splashes, spills, or spattering.
6. Students should prepare for each laboratory activity by reading all instructions before they come to class. Follow all directions implicitly and intelligently. Make note of any deviations announced by your instructor.
7. Labels and equipment instructions should be read three times before using. Be sure that you are using the correct items and that you know how to use them.
8. No food, beverage, or smoking is permitted in any science laboratory.
9. Never taste or touch chemicals with the hands unless specifically instructed to do so.
10. While in the laboratory using solutions, speci-

mens, equipment, or materials, hands should be kept away from the face, eyes, and body. Gloves should be worn when handling some reagents. Hands should be washed thoroughly with soap at the conclusion of each laboratory period.

11. Students should note the location of the emergency shower, eye and face wash fountain, fire blanket, and fire extinguishers and know how to use them.
12. Students should know the proper fire drill procedure.
13. Long sleeves should be rolled up above the wrist. Ties, coats, and sweaters should be removed. Long hair should be tied back during laboratory activity, especially when an open flame is nearby. (Use hairnets, if necessary.)
14. Student apparel should be appropriate for laboratory work. Long hanging necklaces, bulky jewelry, and excessive and bulky clothing should not be worn in the laboratory.
15. Work areas should be kept clean and tidy.
16. Students should always clean, and wipe dry, all desks, tables, or laboratory work areas at the conclusion of each laboratory activity.
17. Broken glass should be removed from work area or floor as soon as possible. Never handle broken glass with your bare hands. Use counter brush and dustpan and/or wet cotton wads held with forceps and dispose in proper containers.
18. All solid waste should be thrown in separate waste baskets, jars, or other designated receptacles. Do not discard any solids in the laboratory sinks, especially glass items such as tubing or cover glasses.
19. Matches should not be thrown into waste paper baskets. A metal container with sand should be provided for them.
20. Litmus paper, wooden splints, toothpicks, etc. should be disposed of in the same manner as matches.
21. Gas burners should be lighted only with a sparker in accordance with your teacher's instructions.
22. Extreme caution should be exercised when using a burner. Keep your head and clothing away from the flame and turn off when not in use.
23. Do not bring any substance into contact with a flame, unless specifically instructed to do so.
24. Only lab manuals and lab notebooks are permitted in the working area. Other books, purses, and such items should be placed in your desk or storage area.
25. Students are not permitted in laboratory stor-

age rooms or teacher work rooms, unless directly instructed to do so.

26. Upon first entering the laboratory, students are not permitted to touch laboratory equipment until directed to do so.
27. Any science project or experiment which requires the use of dangerous drugs or chemicals which are caustic or poisonous, must be approved by the teacher in accordance with school policies.
28. Always twist, never push glass tubing into stopper holes. Lubricate stopper hole and glass tubing with water or glycerin to insert easily. Always use glass tubing with fire polished ends.
29. Students should be alert and proceed with caution at all times in the science laboratory. Take care not to bump another student and remain in your lab station while performing an experiment. An unattended experiment can produce an accident.

The Occupational Safety and Health Act of 1970 established two agencies, one of which has issued a wide range of safety and health standards and has the authority for enforcement.

During its first two years, OSHA was obliged to issue many regulations quickly. As a result, it seldom went through the lengthy procedure of drafting its own rules. Instead, it adopted many voluntary "consensus standards" previously developed by such groups as the American National Standards Institute, National Fire Protection Association, Compressed Gas Association, American Conference of Governmental Industrial Hygienists, and American Society for Testing and Materials.

In more recent years, OSHA has drawn up many of its regulations on its own, often based on recommendations forwarded by the National Institute for Occupational Safety and Health (NIOSH). This practice is expected to become more and more the norm in the future.

OSHA and the States

Federal OSHA regulations apply only to those states which do not have their own OSHA-approved plans for protecting safety and health. In states with OSHA-approved plans, the safety and health rules are enforced by state OSHA officials rather than by federal compliance officers. To be OSHA-approved, a state safety program does not have to be identical to OSHA's program. It must, however, be "at least as effective as" the federal OSHA program.

As of early 1977, twenty-three states had an OSHA-approved plan that enables them to adopt and enforce their own safety and health regulations. These plans regulate employers in both private organizations (such as companies and private universities) and state organizations (such as state universities, hospitals, and laboratories). Teachers who are interested in determining whether there is a plan in their state and what provisions are required, should contact their district safety officer, or phone a regional or area office of OSHA.

In the remaining twenty-seven states (along with six other jurisdictions, such as the District of Columbia, Puerto Rico, and the Virgin Islands), federal OSHA regulations control the safety and health practices of all private organizations. Each of these states, however, enforces its own rules governing state and local organizations (including school systems).

Inspection of Workplaces

OSHA has an expanding staff of compliance officers who inspect work sites to see whether they meet the agency's safety and health standards. Almost always, these inspection are made without advance notice. However, advance notice may have to be given if, for example, there is an employee complaint about a possibly hazardous condition that occurs during certain phases of an operation. An OSHA spokesman has stated: "In about 90 percent of the cases, we have inspected facilities without prior notice because we want to see the conditions as they usually are and not cleaned up for our benefit."

During an OSHA inspection, the agency's officials normally are accompanied by both an employer representative and an employee representative. The OSHA compliance officer makes note on all alleged violations. Later, the employer may receive a citation listing all alleged violations and the proposed penalties.

The employer is also informed as to the time he is allowed to correct the cited violations. Some may be readily corrected, such as obstructed aisles, unmounted fire extinguishers, or unsecured compressed gas cyclinders. Others may have to be corrected immediately because they constitute a serious imminent danger. In the case of other violations, such as those requiring the installation of a stairwell or the purchase of hard-to-get equipment, the employer may have as much as a year to correct a deficiency, however temporary protective measures must be provided. Later OSHA officials reinspect the workplace to make sure violations have been corrected within the specified time.

It is recommended that teachers be aware of this federal act that was passed to provide health and safety standards primarily for private industry. Many states that have a state plan approved have extended these standards to include public agencies, which include the schools. Questions that may be raised regarding a particular safety practice should be referred to one of the ten regional or 121 area offices of OSHA.

Safety Procedures

First Aid

First Aid is the immediate care given to a person who has been injured or has been suddenly taken ill. Its purpose is to protect rather than treat and is used in emergency situations where medical assistance is not immediately available.

It is the responsibility of each teacher to know how to proceed in the event a student becomes ill or is injured in the classroom laboratory. All teachers should receive first aid training from the American National Red Cross.

Do's in First Aid

1. Obtain staff assistance—send for school nurse and principal.
2. Handle the person as little as possible until the injury evaluation is complete and moving may be indicated.
3. Check for difficulties in breathing. Start artificial respiration if breathing is absent.
4. Check for presence or absence of bleeding, and if significant, control it.
5. Check for presence or absence of shock and initiate management, if necessary.

Don'ts in First Aid

1. Don't panic, remain calm.
2. Don't give liquids (or medicines) to an unconscious person.
3. Don't try to arouse an unconscious person.
4. Don't incise the skin, break blisters, etc.
5. Don't diagnose.
6. Don't give medical advice.
7. Don't reduce dislocations.
8. Don't transport in your private car.
9. Don't send a student home before consulting parents.

How to Proceed in Case of Injury or Illness to a Student

It is essential to obtain medical aid in every case of serious injury or illness, in all cases of injury to the eye, and whenever in doubt. School employees should not diagnose, prescribe, treat, or offer medication, but may render first aid.

Serious injury or illness:

—Do not move patient until extent of injury is determined.

—Call the school nurse and render first aid.
—Notify the principal.
—Notify parent or guardian immediately and arrange for transportation and care.
—If parent or guardian cannot be reached and student needs immediate health care, notify the police who should provide an ambulance if needed. Have competent person accompany the student if the parent is not present.
—Complete appropriate accident report form (see sample, page 102).

Red Cross First Aid Courses

Standard First Aid and Personal Safety—designed for the general public, to prepare people—by providing them with knowledge and skills—to meet the needs of most situations when emergency first aid is required and medical assistance is not excessively delayed.

Basic First Aid—teaches skills and knowledge critical to saving life and minimizing the severity of injuries. Developed on the fifth grade reading comprehension level, the course is designed primarily for use in schools.

Advanced First Aid and Emergency Care—designed for use by persons who are responsible for giving emergency care to the sick and injured. It provides the essential information for developing the functional first aid capabilities required by policemen, firemen, and other special interest groups. Science teachers should consider taking this advanced course.

CPR Basic Life Support—Cardiopulmonary Resuscitation—CPR training teaches the correct techniques to provide heartbeat and breathing in victims of cardiac arrest by means of external chest compression and mouth-to-mouth resuscitation.

The American National Red Cross also offers instructor training courses for all of the above first aid courses.

First Aid Kits

First Aid kits can be either purchased or can be assembled from improvised materials. All kits, whether purchased or improvised, are satisfactory if the following points are observed in their selections:

—The kit should be large enough and should have the proper contents for the place where it is to be used.
—The contents should be arranged so that the desired package can be found quickly without unpacking the entire contents.
—Material should be wrapped so that unused portions do not become dirty through handling.

Types and sizes of kits to meet specific needs should be selected and supplied with items recommended by the local school board and a consulting physician. As a minimum, each science laboratory should have a kit containing the following items:

2 units—1″ adhesive compress
2 units—2″ bandage compress
2 units—3″ bandage compress
2 units—4″ bandage compress
1 unit—3″ x 3″ plain gauze pads
2 units—gauze roller bandage
1 unit—eye dressing packet
4 units—plain absorbent gauze—½ sq. yd.
3 units—plain absorbent gauze—24″ x 72″
4 units—triangular bandages—40″
1 unit—tourniquet, scissors, tweezers

Reference: *Standard First Aid and Personal Safety,* The American National Red Cross.

Fire Prevention and Control

It is the responsibility of each science teacher to be prepared to act deliberately and intelligently in the event of a classroom fire. Your first concern should be to evacuate the area.

Many reactions are extremely energetic. This energy usually takes the form of heat or the mechanical energy resulting from the production of large volumes of gaseous products. Combustible materials and potentially explosive substances are present and routinely used in a classroom setting.

It is important that both teacher and student know not only the location of the fire fighting aids available —the blanket, the extinguishers, and the fire alarm box—but also *know how to use them*.

The most common causes of laboratory fires are failure to understand the nature of the supplies or equipment being used; carelessness in the handling of supplies or equipment; horseplay; and permitting combustible debris (such as paper towels) to accumulate.

The principal concern in any materials fire is to immediately move students from the fire area. The teacher must quickly determine the immediate and potential danger from the fire. If there is any chance that the fire might spread or represent a danger to the classroom or students, the fire alarm must be sounded. It is the teacher's responsibility to know the location of the fire alarm box nearest the classroom. *The first responsibility of teachers is to get students out of the area.*

Another common type of accidental fire in the science laboratory are those of clothes and hair when a student leans too close to an open flame. In both cases, *water* is the most effective remedy. A *fire blanket* to smother the fire could also be used. Do *not* use a CO_2 fire extinguisher on an individual. A CO_2 blast could spread the fire and could possibly cause frostbite, thereby compounding the burn.

In case of explosion, immediately turn off burners and other heaters. Stop addition of reagents, assist in treating victims, and vacate the room. Since toxic gases may be present, everyone should evacuate the room until it is decontaminated. Injured persons should be examined and given first aid for burns, cuts, and chemicals on the skin and in the eyes as appropriate and then referred to proper medical treatment.

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Fire Fighting

1. As a general rule, the physical area immediately surrounding a fire should be cooled with an extinguisher to prevent the flames from spreading, then the base of the blaze extinguished, and finally, the scattered remnants of the fire smothered.

2. The first step in an electrical fire is to pull the plug. Use a carbon dioxide extinguisher, since it is a non-conductor of electricity. Exercise caution to avoid becoming a part of the circuit by only handling insulated material.

3. There are four general classes of fire and the use of the proper type of extinguisher for each class will give the best control. The classification of fires here is based on the type of material being consumed.

Class A—Fires in wood, textiles, paper, and other ordinary combustibles.

This type of fire is extinguished by cooling with water or a solution containing water (loaded steam) which wets down the material and prevents glowing embers from rekindling. A general purpose dry chemical extinguisher is also effective by fusing and insulating.

Class B–Fires in gasoline, oil, paint, or other flammable liquids that gasify when heated.

This type of fire is extinguished by smothering, thus shutting off the air supply. Carbon dioxide, dry chemical, and foam are effective on this type of fire.

To use a *dry chemical* or *carbon dioxide* extinguisher, pull the pin, point the nozzle at the flame, and squeeze the handle. Do not hold the *horn* of the carbon dioxide extinguisher with your hands; use the handle since the carbon dioxide causes supercooling of the horn.

To use a *foam extinguisher*, invert the extinguisher and point the nozzle in such a way as to cause the foam to float over the fire; do not point the stream at the flame. This extinguisher does not have a cut off valve and must be completely expelled.

Class C—Fires in live electrical equipment.

This type of fire is extinguished by using a non-conductive agent. A carbon dioxide extinguisher smothers the flame without damaging the equipment. A dry chemical extinguisher is also effective. Whenever possible the source of power to the burning equipment should be cut off.

Class D—This classification includes fires in combustible material such as magnesium, titanium, zirconium, sodium, potassium, and others. A special extinguisher powder, unlike regular dry chemical and general purpose dry chemical, may be applied by scoop. Dry sand may also be used to extinguish small Class D fires. Apply by scoop.

Be aware that some multipurpose A.B.C. fire extinguishers are now available for industry, school, and home use.

Eye and Face Protection

The science curriculum involves many activities that present danger from flying particles or objects, from splattering hot or corrosive substances, or from damaging radiation. Since the eyes are especially vulnerable to injury from such hazards, teachers must take measures to provide eye protection during these activities. If certain experiments are especially dangerous and adequate protection is not available, "hands-on" experiments should be eliminated from the program, and replaced by controlled demonstrations or films.

General Information

During the past few years about three-fourths of the States have passed laws that require students to wear "eye protective devices" while taking part in certain types of activities. Many of these laws are quite specific in listing the courses (chemistry and physics) as well as the types of activities that require the use of these devices. Check your local and state regulations.

In general, these statutes require that adequate protection be provided for the eyes of students, visitors, and teachers who are engaged in, or observing activities that are likely to cause physical injury to the eyes. These might include, but are not limited to, such activities as, "working with hot liquids or solids or with chemicals which are flammable, toxic, corrosive to living tissues, irritating, strongly sensitizing, radioactive, or which generate pressure through heat, decomposition, or other means."

Also included in many of these eye protection statutes may be a standard for the quality of goggles. The one that seems to be the most commonly used is that set by the U.S.A. Standards Institute Safety Code for Head, Eye, and Respiratory Protection (Z2.1-1959), promulgated by the United States of America Standards Institute, for industrial quality eye protective devices. A portion of that standard was revised in 1968 and became Z87.1-1968, Practice for Occupational Eye and Face Protection.

The type of eye protection device needed depends on the particular job to be done. For most laboratory work, safety glasses with clear side shields are adequate as long as eye-wash fountains are near at hand. However, the rule of thumb is to assume that accidental exposure to chemicals or particulates will occur and that the wearing of approved chemical goggles should be worn in any operation when these dangers are present. (Models are available to be worn over spectacles.)

Full face shields should be worn when working with glassware under reduced or elevated pressure and with glass apparatus used in combustion or other high temperature operation.

It is strongly recommended that the wearing of contact lenses in the laboratory be discouraged; if used, protection by goggles or face shield should be required. Wearing of contact lenses in the laboratory with safety glasses should not be permitted since there is a distinct possibility that chemicals may infuse under the contact lenses and may cause irreparable eye damage.

The Food and Drug Administration requires all eyeglasses and sunglass lenses sold to the general public be of shatter-resistant material. Be aware that, although this regulation improves the protection to the general public, such eyeglasses cannot be considered adequate for science laboratories which require industrial quality eye protective devices. The principal difference is that the FDA requires hardened lenses with a minimum thickness of 2mm, while the ANSI standard requires a minimum thickness of 3mm, lens-retaining frames, non-flammable frames, and other attributes not covered by the FDA regulation.

Prior to any work in the chemical laboratory, plans and facilities must be established for action to be taken in the event of splashing of chemicals in or near the eye. Adequate attention to the immediate flushing of the eye with clean tempered water from a gentle flowing source such as an eye-wash fountain for a predetermined time (10 to 15 minutes is the usual recommendation) should be followed by prompt treatment by the student's family physician or an opthalmologist especially alerted and acquainted with chemical injuries.

Eye Safety Devices

Eye safety devices are recommended for a science program on the following basis:

Device	Recommended Allowance
1. Goggles, plastic splashproof	1 class set (40)/each high school laboratory
2. Face shield, quick adjustable	1/each teaching station, prep room and project room
3. Case, portable for 36 spectacles	Same as No. 1
4. Shield, safety	1/prep room

The devices described above may be expected to provide eye protection for personnel in the following manner:

Goggles—Protection against impact and splash—reduction of dust and fumes.

Face Shield—Partial protection of face against impact and splash.

Safety Shield—Group personal protection from splash and impact.

These devices should not be considered 100 percent effective against all potential eye hazards. Appropriate combinations of devices may be used for optimum protection.

Establishment of an Eye Protection Program

In order to establish an effective eye safety program, teachers should:

1. Orient students to the need for and the use of eye protection devices.
2. Consider eye safety when planning each science activity.
3. Establish routine procedures for the distribution of the individual eye protection devices when needed and for their subsequent return to the storage case.
4. Maintain strict standards for cleanliness, since eye protection devices will usually be shared by several persons, although it is best for each student to have her/his own pair. Students with unhealthy, possibly contagious, skin or eye conditions should be encouraged to purchase personal safety glasses; or a pair should be reserved for their exclusive use.
5. Establish a definite readily accessible location in the designated areas for each type of eye protection device.
6. Demonstrations involving hazards to the eyes should be arranged so as to shield both pupils and teachers from any danger. The *safety shield* should be used to protect all in the general area as well as the face shield and/or goggles to protect the teacher and students. Size of apparatus and quantities of reagents used in a demonstration should be limited based on the potential hazard that may occur if there should be an accident.
7. Assure that all persons *performing* science laboratory activities involving hazards to the eye wear no less than approved eye protection devices. All persons in dangerous proximity to such activities must be likewise equipped. For example, in chemistry laboratory experiments involving hazardous substances or procedures, *all* persons must be appropriately protected; students with goggles or face shields, visitors with safety glasses.

8. Consider the special requirements of storerooms, preparation rooms, and project room activities. Because of the greater probability and severity of many eye hazards in storerooms, preparation rooms, and project rooms, all persons performing or observing hazardous activities in these areas should be equipped with splashproof chemical goggles and/or face shields.

Specific Hazardous Activities

Eye-protection devices as prescribed by ANSI standard Z87.1-1968 should be provided for participants and observers in the following (but not limited to) situations:

Impact Hazards

—Pneumatic pressure or evacuation operations, including pressure cooker
—Operation of power tools
—Operation of centrifugal (centripetal) devices
—Projectile and collision demonstrations
—Handling of elastic materials under stress; e.g., springs, wires, rubber, glass, etc.
—Working with or igniting explosive or implosive devices or substances
—Working with hot, molten metals
—Hammering, chipping, grinding rocks, minerals, and metals
—Cutting or breaking glass

Hazardous Substances

—Pouring, pumping or dispensing corrosive substances
—Heating or electrolysis of chemicals
—Mixing chemicals which react violently
—Preserving and straining biological specimens
—Cleaning and sterilizing with corrosive substances, including ammonia, detergents, and solvents

Hazardous Radiation

—Direct viewing of the sun
NOTE: There is *no safe eye protection* against this hazard. Avoid this activity.
—Use of infrared and ultra-violet sources
NOTE: An approved welders face shield is effective but it is recommended that these sources be shielded from direct view.
—Use of lasers

NOTE: Lasers represent a special hazard to both eyes and skin. Knowledge of the equipment should be obtained before any use is contemplated.

Glassware

Glass has many properties which make it especially suitable for laboratory work, but the use of glass can be hazardous. Improper or careless handling of glass equipment can cause many accidents and injuries. The following are safety recommendations for the use of glass adapted from the National Safety Council.

Cutting

1. To cut glass rods or tubing:
   a. Support the tubing in a notch or groove on on the edge of the bench.
   b. Hold a sharp file or glass knife directly over the tubing and the bench; then, with a single stroke, make a small deep cut in the tubing.
   c. Moisten the file and scratch the cut slightly.
   d. Wear gloves or wrap the glass in a towel before breaking it apart.
   e. Hold the tubing with the cut away from the body; press thumbs firmly behind the file scratch; pull hands out and back.
2. Use the hot wire method on tubing of 20 mm. or larger: draw the wire tightly around the glass over the scratch, heat the wire by low potential current; turn off the current and run a stream of water along the wire.
3. The ends of all glass pieces used in the laboratory must be squared and fire polished. The steps to follow when fire polishing a glass tube are:
   a. Hold the glass tube so that the sharp end is in the top of the flame of a gas burner.
   b. Rotate the tube so that all sides are heated evenly, causing the sharp edges to melt and become smooth.
   c. Place the fire-polished tube on an asbestos mat or some other insulation material while it cools.

Stoppers

1. Do not force glass into stopper holes. The end of the glass tube should be tapered to fit the stoppers, and the holes should be made large enough to fit the glass tube.
2. To put glass into a stopper, first run a cork borer through the stopper. Then, after slipping the glass tube inside the cork borer, withdraw the borer, leaving the tube in the stopper.

3. Use glycerin to lubricate glass and rubber during assembly. Glycerin keeps the connection between the glass and rubber from freezing so they can be pulled apart easily.
4. In removing glass rods, tubing, thermometers, and funnel stems from old stoppers, it is safer to cut away the stoppers than to risk breaking the glassware. When cutting a stopper, support it against a table top, not against your hand.

Clamping

1. Clamping glassware prevents breakage. Wrap the glass in asbestos cloth or asbestos paper. (Rubber will do if the apparatus is not to be heated.) Do not strain the glass. Excessive tightening of the clamp will only bend the clamp or break the glass.

Heating

1. Use care in selecting glassware for high temperature heating. Never use soft glass. Glassware which is to be treated should be Pyrex or a similar heat-treated type.
2. When heating a flask or beaker over an open flame, put the flask or beaker on an asbestos center wire gauze or an asbestos insulated ring. The wires in plain gauze produce hot spots which may break the bottom of the container.
3. Do not permit flames to lap over the edges of gauze; localized overheating will crack glassware.
4. Use an asbestos or glass cloth pad with hot plates. Pads prevent glassware from breaking when placed on the hot plates, and also prevent scratching.

Chemical Reactions

1. Do not use glassware for mixing potentially explosive compounds. Heating volatile compounds, mixing acid solutions and other potentially dangerous reactions should be conducted behind a safety shield.
2. Do not use soft glassware containers for reactions which produce heat, such as the mixing of acid and water.

Frozen Joints

1. Frozen glass-to-glass surfaces, which occasionally occur in stopcocks, ground joints and glass-stoppered bottles, present a particular hazard unless extreme care and patience are exercised. Wear gloves or protect the hands with a towel, and apply a stream of hot water to the stopper.

Maintenance

1. When bottles which have tightly fitting closures are filled with liquids, sufficient air space

should be left in the neck of the container to permit expansion.

2. Laboratory glassware should never be used for eating or drinking purposes.
3. Long glass tubing should be reduced in length before it is carried any distance. Carry tubing vertically and give wide berth to corners.
4. Do not use glass reagent bottles for highly flammable materials, such as ether. Store bottles of flammable liquids, hydrogen peroxide, etc., in metal receptacles large enough to contain the entire contents of the bottle in the event of breakage.
5. All glassware should be free from nicks, scratches and cracks. If glassware is broken, use a dustpan and brush to remove the broken pieces immediately.
6. Glassware to be discarded should be placed promptly in a specially painted, conspicuously labeled "broken glass" can. It is important that glass be separated from other laboratory trash, and that the janitor or person emptying laboratory trash holders be able to tell what is broken glass and what is not.

Alternate Materials

1. Many laboratory items are now available made of plastics. These are usually unbreakable at ordinary temperatures and, therefore, can be substituted safely for glass in many operations. Several different plastic compositions used in laboratory ware have different melting points and resistance to chemicals. Knowledge of their stability and chemical inertness is necessary before placing them in general use. Where applicable, these items are recommended.

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Health Hazards

Intelligent, safe handling of toxic or corrosive chemicals is promoted by an understanding of their physiological and toxicological effects. These harmful effects can take place by any one of three means of entry into the human body.

1. **Ingestion.** Harmful substances taken by mouth may damage the tissue of the digestive tract or find their way into the bloodstream. Small quantities of some poisons may be neutralized by the digestive juices or removed by the liver without causing damage. No chemical should be tasted without specific instructions from the teacher. Laboratory glassware should never be used for eating or drinking purposes.
2. **Absorption.** Under certain conditions, the human skin can be penetrated by many substances. Liquids, particularly organic substances which dissolve the fatty oils in the skin, can be absorbed through the skin more easily than gases or dusts. Skin punctures or wounds (abrasions) may allow the introduction of harmful substances directly into the bloodstream. Keep this in mind and wash the hands frequently, especially at the conclusion of the laboratory period. Avoid contact with materials or wear rubber gloves or plastic gloves and protective clothing if contact is possible. Skin irritants have a direct chemical or physical action on the skin, combining with it to form new compounds or extracting from the skin some of its essential constituents. Skin irritants operate in one or more of the following ways:

a. Dissolve the ketatin (alkalies, strong soaps, and sulfides).
b. Dissolve or emulsify the fat and cholesterol (organic solvents, and alkaline detergents).
c. Precipitate proteins (tanning agents and salts of heavy metals).
d. Oxidize the skin (bleaches and strong oxidizing agents such as perchlorates and permanganates).
e. Dehydrate the skin (inorganic acids, anhydrides, and hygroscopic chemicals).
f. Act as reducing agents (some organic acids and sulfides).

3. **Inhalation.** The most common method of introduction of poisons into the body is through the respiratory tract. Gases and dusts are generally more easily absorbed into the blood stream through the lungs than by ingestion or absorption. Gases, fumes, and dusts which may cause harmful effects when inhaled may be classified as follows:

   a. **Asphyxiants** do not directly injure the respiratory tract but cause oxygen deficiency in the body tissues. Simple asphyxiants like nitrogen or hydrogen are harmful only to the extent that they displace the oxygen. Chemical asphyxiants such as carbon monoxide or carbon dioxide (dry ice) reduce the oxygen carrying capacity of the blood. Cyanide and cyanogen compounds stop oxidation in the tissues by poisoning the oxidation catalysts.

   b. **Irritants** damage the tissues of the respiratory tract and cause inflammation of the respiratory passages. Among these are ammonia, hydrogen sulfide, chlorine, bromine, hydrogen chloride, and phosphorous halides in relatively small amounts. In larger amounts such materials as hydrogen sulfide and chlorine are extremely toxic.

   c. **Metal fumes** have a wide diversity of harmful actions. Some, such as mercury and lead, are especially tissue poisons and can cause serious illness and death. Others such as zinc may produce nausea and fever. If there is reason to heat mercury, it should be done in the hood.

The following chemicals may cause a health hazard by one or more of the three means described above.

1. **Poisonous compounds of sulfur, phosphorous and nitrogen.** The strong mineral acids (hydrochloric, nitric, phosphoric, sulfuric, etc.), in addition to being extremely corrosive to the skin, give off vapors which are very irritating to the respiratory tract. Phosphorous halides are strong respiratory irritants. They form strong acids on contact with water and therefore cause severe tissue burns when inhaled. Hydrogen sulfide is nearly as toxic as hydrogen cyanide. Nitrogen oxides are extremely dangerous because of their delayed action. Harmful or even fatal quantities can readily be inhaled without immediate noticeable results. Pulmonary edema usually results from extended inhalation.
2. **Halogens.** Chlorine is a strong and dangerous lung irritant. Bromine is corrosive to the skin,

causing burns which may ulcerate and heal slowly. Its vapor is highly irritating to the respiratory tract. Since these gases are denser than air, evacuation to higher areas is advised.

3. **Carbon monoxide.** Carbon monoxide is a chemical asphyxiant since it combines with the hemoglobin of the blood and renders it ineffective for the transport of oxygen.

4. **Cyanides.** Hydrogen cyanide is a highly toxic, colorless gas with the odor of bitter almonds. It is readily absorbed through the skin at high concentrations. Hydrocyanic acid and its simple soluble salts are among the most dangerous of all poisons because of their rapid action.

5. **Hydrocarbons.** Saturated aliphatic hydrocarbons are relatively harmless from the toxicological point of view, the lower homologues being less harmful than the higher ones. From pentane on up they are narcotic, convulsive, and irritant in high concentrations. Unsaturated aliphatic hydrocarbons, including acetylene, have simple asphyxiant and anesthetic properties. Cyclic hydrocarbons are more potent than open chain hydrocarbons. Aromatic hydrocarbons are much more toxic than the aliphatics. Prolonged exposure to benzene and toluene has a destructive influence on blood forming organs. They also have an acute narcotic effect. Permanent damage to the liver and kidneys may result from chronic exposure. Prolonged exposure to or use of carbon tetrachloride vapor should be avoided.

6. **Alcohols.** The alcohols, methanol excepted, increase in anesthetic power with increasing molecular weight. Butanol and pentanol, in addition, are irritant and have a poisoning action on protoplasm. Methyl alcohol (menthanol) is poisonous and contact as well as inhalation is to be avoided. Ingestion or prolonged inhalation can cause blindness.

7. **Aldehydes and ketones.** The aldehydes are primarily irritants but they have some narcotic action. Formaldehyde is poisonous and a concentration of five parts per million (0.0005%) is considered the threshold of a safe working atmosphere. The ketones are narcotic, but in comparison to other volatile liquids, are less harmless.

8. **Ethers.** Ethers are powerful narcotics acting rapidly on the central nervous system. They are dangerous if inhaled in moderate quantities.

9. **Esters.** Esters vary widely in anesthetic and irritant properties from the very mild action of

ethyl acetate to the poisonous, irritant and vesicant action of formic acid esters and dimethyl sulfate.

10. **Acids**—
    a. **Acetic acid** is considerably more corrosive to the skin than is generally believed. Even at room temperature the vapor is highly irritating to the eyes, nose, and throat.
    b. **Chromic acid** is a strong oxidizing agent. Precautions should be taken to avoid skin contact or inhalation of the dust. This acid will ignite ethanol and similar liquids on contact.
    c. **Hydrochloric acid** (concentrated) fumes strongly. Both the solution and the fumes are corrosive to the skin and the respiratory tract.
    d. **Nitric acid** is a powerful oxidizing agent. Concentrated solutions may cause combustion of reducing agents. In addition, it reacts with many materials to produce dense gases of highly toxic red/brown oxides of nitrogen. Because of their delayed action, it is possible to inhale a dangerous concentration of these oxides without much initial discomfort or apparent injury.
    e. **Sulfuric acid** (concentrated) chars and destroys tissues on contact because of its avidity for water. Its gases are irritating to the respiratory tract. The use of concentrated sulfuric acid by students should be avoided.
    f. **Phenol** (carbolic acid) is readily absorbed through the skin and is quite toxic. It produces a tingling sensation followed by a loss of feeling. The skin becomes white and wrinkled and then turns brown and sloughs off. This is not a true corrosive action, but is local gangrene caused by a destruction of the blood supply to the affected area.

11. **Alkalies.** Sodium and potassium hydroxide, and their concentrated solutions, can cause severe burns to the skin and eyes upon contact. Dissolving the solid alkali generated so much heat that there is often boiling and spattering even when cold water is used. Ammonia is a strong irritant and in excessive concentration can cause death from bronchial spasm. It is not, however, particularly harmful in concentrations small enough to be just uncomfortably irritating. Its aqueous solutions are particularly harmful if splashed in the eyes.

12. **Mercury.** Mercury poisoning can occur by contact with exposed skin surfaces, ingestion, or inhalation of vapors. Free mercury vaporizes

at room temperatures and if quantities are left exposed or spills are not thoroughly cleaned up, inhalation of these vapors can be hazardous. Wherever possible, mercury should be used in a completely closed system. It is recommended that trays of sufficient size and volume be placed under all apparatus and instruments containing mercury. The area where mercury is used should have smooth hard finished flooring and bench tops with a minimum of cracks and crevices. If a mercury spill occurs, immediately pick up as necessary. The bulk of the spill may be picked up with specially designed vacuum cleaner or aspirator. Small droplets remaining may be absorbed by amalgamation on clean copper metal. The exposed area should then be scrubbed with a solution of calcium polysulfide or "HgX." This treatment will convert any remaining metallic mercury to relatively harmless sulfides. Acute exposure to mercury vapors occurs when the unconfined metal is exposed to high temperatures, e.g., a broken thermometer in a hot oven or a container of hot liquid. In cases of this kind, the area should be immediately evacuated. Clean-up operations should be undertaken only after temperatures have been reduced and the area thoroughly ventilated. Students should not be allowed to amalgamate coins with mercury. Continued handling of the amalgamated coins can be harmful.

Storage

The necessity of storing a great variety of chemicals with a diversity of properties and reactivities creates special hazards which must be readily recognized and prevented.

Any room used for the storage of chemicals should be well ventilated, dry, and protected from sunlight or localized heat (heating vents or pipes). It should have adequate explosion-proof lighting. It should be kept locked when not in use, and only the instructor should have access to it.

Enough space should be available so that there is no crowding. Shelving should have enough depth so that the articles do not become easily dislodged. A rim guard as an added safety measure is also recommended. Low level storage is preferred over high level storage areas. Toxic chemicals, large glassware and heavy articles should always be stored on a low level. When shelving cannot be safely reached from a standing position, a step-ladder or other appropriate device should be available and used, not chairs or stools. The following are some specific recommendations for storage.

1. Periodic on-site inspections of chemical storeroom facilities should be made. It is recommended that chemicals be placed in the categories of control and general storage. Control storage includes flammable, oxidizer, and other chemicals where an inventory system is maintained. The following should be checked:
   a. Maximum quantities per storage area as they comply with safety standards.
   b. Flammable storage normally in one gallon safety cans or smaller, placed in metal cabinets. These include: gasoline, kerosene, methyl acetate, methyl alcohol, methyl ethyl ketone, petroleum ether, propyl alcohol, pyridine, toluene, turpentine, and xylene.
   c. Oxidizer storage in a separate lockable cabinet behind an opaque door and separated from *all other* chemicals. These include: ammonium nitrate, potassium chlorate, nitrate or permanganate, sodium nitrate, and the metallic sulfates and permanganates.
   d. Other control storage should contain the remainder of control chemicals which may be stored with other chemicals. These include:

powdered or granular charcoal, glycerine, magnesium powder or ribbon, concentrated nitric and sulfuric acids, red or white phosphorous, sulfur and zinc powder.

e. Inventory of all chemicals should be kept up-to-date.

f. Hazardous and unidentifiable or unlabeled chemicals should not be kept in schools. Dispose of these, as well as, outdated chemicals in an appropriate manner. (Reference: *Laboratory Waste Disposal Manual*, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009, 1975.)

g. Known carcinogens are not to be kept in schools. (See page 99.)

h. Security for control chemicals should take place by having them stored in locked cabinets or lockable storage or preparation rooms.

2. Phosphorous. White phosphorous must be kept under water. This form must also be cut under water. If cut in the open air, the friction may be sufficient to ignite the material with dangerous results. Use red phosphorous in place of white phosphorous when possible. Red phosphorous should be made available for student use only in small quantities. When red phosphorous burns it produces toxic phosphorous pentoxide. Red phosphorous fires are very difficult to put out. Red phosphorous resublimes as white phosphorous. Residues of phosphorous should be completely burned in the hood before depositing in the waste jar.

3. Metallic sodium, potassium, calcium, and calcium carbide must not be stored above water solutions or vessels containing water. Metallic sodium or potassium, after the original container has been opened, must thereafter be kept under kerosene and checked on a regular basis.

4. Bottles containing acids or organic volatile liquids should never be placed near heating pipes, nor allowed to stand in the sun; dangerous gas pressure may build up.

5. Care must be exercised in the storage and use of ether as they react slowly with oxygen to form explosive peroxides. These peroxides are less volatile than the others and will concentrate as evaporation occurs. Presence of peroxides in ether may be detected by shaking a sample in an acidified solution of potassium iodide. Peroxides will liberate iodine, causing a red color. Ether can be freed of peroxide by shaking with a solution of ferrous sulfate, sodium sulfite, or other suitable reducing agent.

6. Small bottled gas cylinders should be secured to prevent upsetting which may result in personal injury and destruction of laboratory facilities.
7. When used in classrooms, large gas cylinders must be kept in the cart provided for their transport. Valves should be kept in perfect working condition. Careful instructions should be issued and close supervision given if students are to use this facility. When not in use, cylinders of flammable gases (i.e., hydrogen) must be secured against movement in an approved storage area.
8. Do not use solid benzoyl peroxide. It is a dangerous chemical, particularly when jars or cans of solid become slightly moist. It should not be kept in a high school laboratory.

Explosives

Picric Acid	Glass Stoppered Bottle (G.S.B.)
Collodions	
Carbon Bisulphide	G.S.B.

***Flammable Liquids**

Crude Petroleum	Tin Can
Benzine, Benzol or Naphtha	Tin Can
Coal Tar	Tin Can
Coal Tar Oils	Tin Can
Wood Creosote	Tin Can
Ether, Ethyl	Tin Can
Varnishes, Lacquers	Tin Can
Acetone	Tin Can
Alcohol, Ethyl	Tin Can
Alcohol, denatured	Tin Can
Alcohol, Methyl	Tin Can
Aldehyde, Ethyl	G.S.B.
Amyl acetate	G.S.B.
Amyl Alcohol	G.S.B.
Kerosene	Tin Can or G.S.B.
Nitrobenzol	Tin Can
Turpentine	Tin Can
Toluol or Toluene	Tin Can
Xylol or Xylene	Tin Can
Essential Oils	G.S.B.
Glycerine	G.S.B.

*Note: When possible, safety cans should be used for storage and dispensing of flammable liquids.

Combustible Substances

Phosphorus white	Under water in glass bottle surounded with sand
Phosphorus red	G.S.B.
Sulphur	Tin Can
Metallic magnesium (strip and powder)	G.S.B.
Camphor	G.S.B.
Rosin	G.S.B.
Pitch	Tin Can
Tar	Tin Can
Venice turpentine	G.S.B.
Burgundy pitch	G.S.B.

Combustible Substances (Cont'd)

Naphthalene	G.S.B.
Shellac	G.S.B.
Resins, Balsams	Tin Can
Pulverized Charcoal	Tin Can
Lampblack	Tin Can
Cotton, absorbent	Paper box
Cotton batting	Paper box
Zinc Dust	G.S.B.

Dangerously Corrosive Chemicals

Glacial Acetic Acid	G.S.B.
Hydrofluoric Acid	Wax bottle in a container of kaolin
Hydrochloric acid	G.S.B. (6 lbs per bottle)
Sulphuric acid	G.S.B. (9 lbs each bottle)
Phenol	G.S.B.
Sodium hydroxide	G.S.B.
Potassium hydroxide	G.S.B.
Acid, chromic	G.S.B.
Acid, nitric	G.S.B.

Peroxides and Other Oxidizing Agents

Hydrogen peroxide	G.S.B.
Sodium peroxide	Tin Box
Potassium peroxide	G.S.B.
Calcium peroxide	G.S.B.
Barium peroxide	G.S.B.
Potassium chlorate	G.S.B. or tin can
Sodium Chlorate	G.S.B. or tin can
Barium Chlorate	G.S.B.
Other metallic chlorates	G.S.B.
Potassium Permanganate	G.S.B.
Sodium permanganate	G.S.B.
Other metallic permanganate	G.S.B.
Bismuth Subnitrate	G.S.B.
Barium nitrate	G.S.B.
Strontium nitrate	G.S.B.
Cobalt nitrate	G.S.B.
Iron nitrate	G.S.B.
Mercury nitrate	G.S.B.
Potassium nitrate	G.S.B. or tin can
Silver nitrate	G.S.B. (brown bottle)
Sodium nitrate	G.S.B. or tin can
Other metallic nitrates	G.S.B.

Substances Made Dangerous by Contact with Water

Calcium Carbide	G.S.B.
Metallic Potassium	Under kerosene in bottle in sand
Metallic Sodium	Under kerosene in bottle embedded in sand
Quicklime	Tin Can
Sulfuric acid	G.S.B.

Labeling

In any classroom it is essential to label both the storage area where the equipment and materials are stored and also the individual item. Marking pens or electric markers may be used to identify equipment by name. Usually labels of a temporary type are more appropriate for containers used for materials, including dry and liquid chemicals.

The labeling of chemical containers in school laboratories is essential for safe operations. Students are not normally familiar with the properties of chemicals; this is especially true in regard to their hazardous characteristics. Proper labeling can lower the potential for accidents occuring that result in personal injury due to misuse, spills, etc.

Chemicals labels should contain the following information:

1. **Name** of chemical and the chemical **formula.**
2. **Degree of hazard.** This is indicated by the use of the appropriate signal word, DANGER, WARNING, or CAUTION. This signal word calls attention to both the hazard and the relative severity.
3. **Statement of hazards.** A word or two to indicate each type of hazard present, such as POISON, CAUSES BURNS, FLAMMABLE, VAPOR HARMFUL, EXPLOSIVE. Some chemicals present more than one hazard; therefore it is necessary to include each significant hazard present with the handling of the chemical.
4. **Precautionary measures.** Precautionary measures are intended to be instructions which describe how users can avoid injury from the hazards given in item three above. Examples include: Keep away from heat, sparks, or open flame; Use only with adequate ventilation; Do not get in eyes, on skin, or clothing.
5. **Instructions in case of contact or exposure.** If accidental contact or exposure does occur, immediate treatment is often necessary to minimize injury. Such treatment usually consists of proper First Aid measures which can be used before a physician can be seen. For example: In case of contact, flush with large amount of

water; for eyes, rinse freely with water for 15 minutes and get medical attention immediately.

To apply the foregoing, the label for hydrocholric acid would be constructed as follows:

1. Hydrochloric Acid—HCl
2. Warning!
3. Causes Burns
4. Avoid contact with skin and eyes. Avoid breathing vapor.
5. In case of contact, immediately flush skin or eyes with large amounts of water for at least 15 minutes; for eyes get medical attention immediately.

When transferring a hazardous chemical from the original container to another, it is important to label the new container. Also, diluting or mixing of chemicals may call for label modification, and indicates the need for developing a new label. This, in addition to reducing the hazards associated with contacting the material, will also lessen the possibility of mixing incompatible chemicals accidently.

The orientation of new laboratory personnel and students to correct labeling is important since this not only reduces the possibility of injury, but also increases knowledge of chemicals that must be handled. Reference: "Guidelines to Precautionary Labeling of Hazardous Chemicals," Manual L-1, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009.

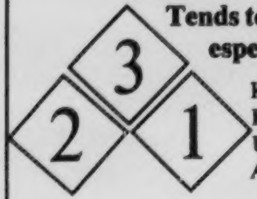
The following is an example of a label that is available through several commercial supply houses. Note the amount of information displayed.

Fire Hazard → Red
4 Extreme
3 Severe
2 Moderate
1 Minor
0 None

Health Hazard → Blue
4 Extreme
3 Severe
2 Moderate
1 Minor
0 None

DIOXANE (1.4-DIETHYLENE DIOXIDE)

WARNING! Flammable—Vapor harmful
Tends to form explosive peroxides
especially when anhydrous



Keep away from heat and open flame.
Keep container closed.
Use only with adequate ventilation.
Avoid prolonged breathing of vapor, or skin contact.
Do not allow to evaporate to near dryness. Addition of water or appropriate reducing agents will lessen peroxide formation.

FLASH POINT 12° C.
(54° F.)

Instability Hazard → Yellow

4 Extreme	Readily explosive under normal conditions.
3 Severe	Explosive if strongly initiated, heated, or water added.
2 Moderate	Normally unstable, or violently reactive with water.
1 Minor	Unstable at elevated temperatures, or reacts with water.
0 None	Normally stable.

Disposal of Chemical Waste

In general, there are three methods employed for disposing of chemical waste materials. First, however, check with your local and state regulations pertaining to chemical waste disposal. The least expensive and most widely used form of disposal is simple dilution of the substance to be disposed. This is the primary means of disposal in most schools. In industry, chemical treatment to make a substance less hazardous, or storage at some facility in a manner which will not permit the substance's escape into the environment, are the other two ways of disposing of chemcal waste.

1. **Liquid wastes:** Corrosive or caustic liquids can be disposed of by pouring down the drain while flushing with copious amounts of water. Liquid wastes should never be disposed of in the waste paper baskets. Flammable liquids should never be poured down the sink drain because the flammable vapors could accumulate in the plumbing and cause a serious explosion. When performing experiments which result in the accumulation of flammable liquid wastes, a safety can should be provided for collection of wastes, and the teacher, if possible, should dispose of the flammable liquid by pouring it into the ground in an area remote from the school.
2. **Solid wastes:** It is excellent practice to use separate containers for flammable solid wastes and non-flammable wastes, especially broken glassware. The mingling of broken glassware with paper and other trash can present a definite hazard to the custodial help performing collection and disposal.

Problems with stopped up plumbing can be avoided if a small plastic container is provided in each sink for solid waste. Suitable plastic containers can be made by cutting the top from laundry bleach bottles. Holes can be punched in the bottom of these containers to prevent them from filling with water.

Surplus Chemicals

Overage or surplus chemicals which, because of toxicity, pollution potential, or explosion danger, cannot be disposed of by dissolving, diluting, and flushing down the drain, should be reported to the department chairperson. Similar steps as in the case of the removal of carcinogenic substances should then be made by contacting the appropriate disposal agency for action. Reference: *Laboratory Waste Disposal Manual,* Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009, 1975.

NOTE: The items below reflect but a few instances of the most common of thousands of incompatible chemicals found in high schools. Teachers who regularly handle less common, but equally dangerous, materials should have in their possession for constant reference:

Manual of Hazardous Chemical Reactions
(latest edition)
National Fire Protection Association
470 Atlantic Avenue
Boston, Massachusetts 02110

Dangerous Combinations

Compound	Should Not Come in Contact With
Acetic Acid	Nitric acid, peroxides, permanganates, ethylene glycol, hydroxyl compounds
Alkali metals; e.g., sodium or potassium	Carbin tetrachloride, carbon dioxide, water, halogenated hydrocarbons
Ammonium nitrate	Acids, inflammable liquids, metal powders, sulfur, chlorates, any finely divided organic or combustible substance
Bromine, chlorine	Ammonia, petroleum gases, hydrogen, sodium, benzene, finely divided metals
Chlorates	Ammonium salts, acids, metal powders, sulfur, any finely divided organic or combustible substance
Hydrogen peroxide	Most metals and their salts, alcohols, organic substances, any inflammable substance
Hydrogen sulfide	Oxidizing gases, fuming nitric acid
Hydrocarbons; e.g., propane, benzene, gasoline, etc.	Fluorine, chlorine, bromine, sodium peroxide
Iodine	Acetylene, ammonia, hydrogen
Mercury	Acetylene, ammonia
Nitric acid (con,)	Acetic acid, hydrogen sulfide, inflammable liquids and gases
Potassium chlorate	Sulfuric and other acids, any organic substance
Potassium permanganate	Sulfuric acid, glycerine, ethylene, glycol
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, carbon disulfide, glycerine, ethylene, glycol, ethyl acetate
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate, similar compounds of other light metals

Unstable Substances

Unstable compounds or mixtures may decompose explosively. A few such compounds are routinely stocked in high school laboratories and require special precautions and very careful handling.

1. **Ether.** Ether, especially uninhibited ether, easily forms peroxides which are very explosive. These peroxides, having a higher boiling point than the ether, concentrate in the distilling flask during distillations or extractions, and can cause disastrous explosions, so never distill to dryness. It is also possible for peroxide to form around the stopper or cap of a container of ether and be detonated by friction when opening the container. For this reason, ether should be procured in containers of not more than four-ounce capacity. Once opened, the contents should be either used or discarded within a month. Annual needs should be anticipated so that fresh stocks are procured each year and not held over from year to year.
2. **Ammonium nitrate.** Ammonium nitrate decomposes exothermically above 160 degrees centigrade producing a large volume of gaseous products. In a confined space or vessel, this self-sustaining reaction develops into a violent explosion.
3. **Formic acid.** Concentrated formic acid is unstable and has been known to explode.
4. **Sodium, potassium, and lithium.** Sodium, potassium, and lithium react violently with water to produce hydrogen which may be ignited or exploded by the heat of the reaction. Sodium is especially capricious and unpredictable. Demonstrations of their reactivity should be done with a cover over the reacting vessel or behind a shield. The alkali metals also react violently with chlorinated hydrocarbons, especially carbon tetrachloride, and with carbon dioxide.
5. **Phosphorous.** White phosphorous spontaneously ignites in the air at temperatures above thirty degrees centigrade. It should be stored, handled, and cut under water. A large culture dish filled with water can conveniently be used for this purpose.

The following substances are very unstable and should not be used in the secondary school science laboratory.

1. **Ammoniacal silver nitrate solutions.** Ammoniacal silver nitrate solutions used for silvering glass or as test solutions (Tollen's Reagent), on standing, may produce an unstable product which detonates violently, sometimes by merely stirring the solution.
2. **Benzoyl peroxide.** In spite of the fact that benzoyl peroxide is prescribed for use in some chemistry programs, it is not recommended for use because of the unstableness of the chemical.
3. **Nitrogen tri-iodide.** Nitrogen tri-iodide is extremely shock sensitive when dry.
4. **Picric acid, metal picrates, perchloric acid, and benzoyl peroxide** are very unstable and should not be stocked in a chemistry storeroom or used in the science program.

NOTE: The notation on certain chemicals in the catalogs to the effect that such substances are nonmailable and must be shipped by express or freight can usually be interpreted as a warning that special care should be exercised in the storage and handling of these chemicals.

Student Laboratory Assistants

Some schools use student laboratory assistants to help the teacher in preparing stock solutions, dispensing chemicals, preparing for laboratory sessions or demonstrations, and other such chores. Special attention to safety is necessary with student laboratory assistants because the main virtue of this system is that, if properly trained, they can function with a minimum of supervision. Due to the potential hazards prevalent, they should never be allowed to work alone in the science room, however. The students' access to the storeroom should be under the direction of the teacher. In the use of laboratory assistants, teachers should not lose sight of the fact that they are students and not employees. The teacher is always responsible for total supervision, especially during any operation involving safety.

Laboratory assistants should be carefully selected and thoroughly trained in safe laboratory techniques. They should have completed the course in which they act as assistants. They should be provided with written instructions on specific duties and operations for which they are responsible. Good practice is to have specific instructions for each manipulation entrusted to them on indexed file cards. The cards for those particular operations which involve special safety considerations could be flagged with a red border.

Student laboratory assistants should abide by the following specific rules:

1. Act under the direct supervision of a teacher at all times and in all places.
2. Do not carry laboratory equipment or apparatus through the hall during the intervals when classes are passing.
3. Do not transport dangerous chemicals at any time (as concentrated acids, bases) unless under the direction of a teacher. They should be transported in proper containers of at least two times the capacity of the containing unit.
4. Do not handle materials on the demonstration desk unless authorized to do so.
5. Do not taste chemicals or other materials.

At the beginning of each term, the assistants should be instructed in general safety precautions. Among these instructions should be included the following:

1. Familiarization with the location, types, and use

of fire extinguishers and fire blanket, shower, eye and face wash, and alarm.

2. Never to operate apparatus or handle chemicals in the laboratory without specific previous instruction.
3. Report at once to the teacher in charge anything in the laboratory that appears unusual or improper, such as broken, cracked, jagged-edge apparatus, "suspicious" looking chemicals, reactions that appear to be proceeding perculiarly.
4. Report at once to the teacher any personal injury sustained—burn, scratch, cut or corrosive liquid on skin or clothing—no matter how trivial it may seem.
5. Eye protection is required at all times in the laboratory.
6. Acts of carelessness are to be avoided and horseplay is prohibited.
7. Unauthorized experiments are prohibited.
8. Laboratory areas and storerooms are not to be used as eating or drinking places.

At the beginning of each laboratory period where there is a special hazard, student laboratory assistants should be specifically instructed regarding the dangers and the precautions that are required.

Extracurricular Activities

The teachers can and should exercise direct control over student science activity in the classroom. However, many worthwhile and desirable science activities are indulged in by students outside the classroom and should be encouraged. Safety consciousness instilled as part of the science instruction program should be such as to influence these outside activities, even though, in some cases, no direct supervision or control is possible.

Field Trips

In addition to the administrative regulations governing students' field trips to places of interest in the local area, certain safety precautions must be taken to preclude accident or injury.

It should be kept in mind that field trips as a school activity are under school sponsorship and the school's responsibility for student safety is not abrogated. Government agencies and private industrial or research facilities usually assume no legal liability for the safety of visitors on their premises.

A first aid kit should be required whenever a group takes a trip away from school. This kit should be checked out from the nurse's office. If the field trip is conducted into an area which is commonly known to be infested by poisonous snakes, the first aid kit should include a snake bite kit. Whenever a first aid kit is used, the nurse should be notified so the contents can be renewed.

Prior to departure on a field trip, it is recommended that the teacher issue Field Trip Permission Forms to each participating students. These forms should be signed by the parent or guardian and returned prior to the trip. These permission slips, as the name implies, give parental approval for the student to make the trip, but in no way diminish the teacher's responsibility for providing for the safety of the students.

Transportation will normally be furnished by school buses. If none are available, commercial buses should be used. There should be an adult, teacher or parent, in charge of the students in each bus. Using private automobiles for field trips is discouraged because the owner of the automobile is legally liable in case of an accident. The fact that the automobile is being used for a field trip does not transfer the liability to the Board of Education. If, however, it is decided to use private automobiles, an adult should be in charge of each car, and the permission form should specify that private automobiles are being used.

As a safety precaution, the teacher should visit the site of the trip prior to taking the students there. In this way the teacher can survey the locality for potential hazards and avoid many of them in advance. In addition, science teachers should prepare their students for the trip, informing them not only of what they are to look for and learn from the experience, but also of what dangers might be encountered.

It is a good rule to develop a printed sheet listing the proper clothing to be worn and necessary equipment or supplies to be taken on the trip. This can also be used as a check list before immediate departure.

To reduce mite or tick infestation, plant poisoning, or scratches, each student should wear clothing that covers the legs. Ankle high shoes or sneakers are better than low tennis shoes or sandals. A staff of some sort should be carried by each student with a warning that it should be used when lifting objects off the ground or searching for anything under leaves or behind brush.

Jars can be dangerous in which to collect specimens on a field trip. Paper, cloth, or plastic bags and plastic vials serve the purpose and may prevent cuts and loss of specimen if the carrier falls.

Identification of poisonous plants, reptiles, and insects should be learned by all who plan to participate. Students taking trips into water should learn to recognize dangerous aquatic or marine animals.

When taking a field trip involving wading, the buddy system should always be used. The teacher should pair off swimers with non-swimmers. When wading is done in water which is over knee depth, it is advisable to have non-swimmers wear a Coast Guard approved life jacket. Students should also be cautioned that when walking in water, their feet should slide along the bottom as a precaution against walking directly into crab holes or over ledges. A long rope attached to a floating ring should be standard field equipment. This can be carried by a member of the party who has no other responsibilities. A prior study of the water bottom is advisable and the students should be briefed on what can be expected from the information obtained concerning water depths, waves, currents, tides, toxic animals, barnacles, sharp rocks, and ledges.

Water pollution is increasing in both fresh and saltwater areas where field trips may be taken. Even when an official pollution warning is not posted in the area, extreme caution must be taken whenever a student is accidentally scratched. This is particularly true when the wound is deep or is a puncture. In such cases medical attention is strongly suggested.

Marine field trips frequently imply skin diving to the more adventurous students. Even though a student is experienced or has had special training by a licensed instructor, teachers are advised to limit underwater observation to snorkeling in the littoral zones. The "buddy system" is a must in such experiences.

No trip should be taken to any body of water unless at least one person in the party is familiar with the latest methods of artificial respiration and with the rules of ordinary water safety as described in first aid handbooks and scouting manuals.

It is inadvisable to have more than ten students per adult in any extensive trips involving an area where students can accidentally wander off, or where the field leader can have his attention drawn to responsibilities other than watching the behavior of the participants.

Home Laboratories

Although teachers cannot, obviously, exercise direct control over experimentation conducted by students in home laboratories, teachers should make every effort to impress upon the students that safety procedures and techniques necessary in the school laboratories are even more important at home, since such experimentation is usually undertaken without supervision.

Ordinarily, home chemistry sets for young people contain comparatively harmless chemicals. The manuals accompanying these sets usually give complete directions for numerous experiments using only the materials provided. Many common household chemicals can be dangerous in combination. Household ammonia, bleaching and dye preparations, lye, preparations for cleaning clogged drains, plant sprays, rat and insect poisons, disinfectants, chemicals in matches and fireworks, turpentine, paint removers, and some garden fertilizers can be mixed to produce hazardous products.

For as little as a dollar and postage, and without knowledge of their parents, students can obtain instructions on how to make everything from tear gas to TNT and thermite. For a few cents more they can obtain the necessary ingredients for making them. The National Fire Protection Association has this to say of this situation:

> "The mail order selling of explosive formulas, chemicals, and kits to teenagers in the name of science is a vicious racket. It feeds on the innate curiosity of teenagers, but instead of gaining them knowledge, in too many cases it costs them hands, fingers, and eyes."

The teacher should continually impress on the students the dangers involved in manipulating chemicals without thorough knowledge of their reactivity. The importance of using minimum quantities of unfamiliar ingredients should be continually stressed. The danger often is in direct proportion to the quantity.

The techniques and precautions regarding electrical and electronic equipment apply equally to appliances found in the home. The dangers involved in careless handling of home appliances, including radios, televisions, etc., should be emphasized as part of the general program of safety instruction. This is especially important since many students do extensive experimentation with electronic kits and components. They should thoroughly understand that the danger of electric shock may be present even after the equipment has been turned off and disconnected.

Safety and Supervision in Project Rooms

A science program should ensure that each student acquires scientific knowledge, skills, and attitudes to the extent of his or her ability. An opportunity for students to demonstrate that they have acquired such knowledge, skills, and attitudes and simultaneously improve them may be provided by individual or small group projects. Science students, especially the more able and creative ones, should be urged to plan and conduct investigations for a class report and/or project for the school science fair.

A project room may be provided to improve the instructional program in the school. The activities which take place in the project room are the responsibility of the classroom teacher, and it is imperative that every effort be made to reduce the possibility of injury to any student. Teachers are legally responsible for all activities they are charged to direct or control. They are liable for any injuries which occur to students. The degree of liability is established by law or jury. The following general points are given for the use of project rooms.

1. Project rooms should not be used as a chemical reagent storage room.
2. Adequate working area should be provided.
3. If venetian blinds are provided, they should be kept open. If not, the door should be left ajar.
4. Only students who have demonstrated a capability for working in the regular laboratory should be allowed to work in the project room.
5. Before beginning work in the project room, students should present outlines of their proposed projects for approval.
6. The teachers should see that all materials and equipment needed for the project room are made available to the students.

7. Normally no more than two students should occupy a project room at any one time.
8. The teacher should make periodic checks of progress.
9. No student should be permitted free access to the project room in the absence of the teacher. This should also pertain to the laboratory.
10. The teacher is responsible for every act of the student in the classroom and other areas to which the teacher is assigned.
11. Students should always wear approved chemical goggles when working in the project room.
12. All accidents and injuries should be reported to the teacher immediately.

Good techniques call for using the smallest quantity to get the desired result. Habitual care in the handling of chemicals should be instilled in the students, and they must be made aware of the possible hazards of not taking all precautions. For this reason, there is a definite place in the instruction for demonstrations of such violent reactions as the thermite reaction, as long as the teacher takes adequate precautions to insure no danger to persons or property. Demonstrations of the fire hazard of flammable liquids and commonly used aerosol sprays such as insect bombs and hair sprays can also be effectively used.

Laboratory Safety

Biology and Life Sciences

The following is a list of safety recommendations for specific experiments frequently performed in biology and life science classrooms.

Epithelial Cell Study

1. Great care should be exercised in securing epithelial cells from the inside of the cheek for study under the microscope. Students should be precautioned against gouging the cheek tissue.
2. Only clean wood splints or the blunt edge of a flat toothpick should be used; pointed instruments, parts of a scalpel, or other instruments, should never be used for this purpose.
3. The splints used to collect the cells should be disposed of in special containers immediately after use.

Use of Formalin

1. Specimens preserved in formalin should be thoroughly washed before being handled. When removing specimens from formalin solution, rubber gloves should be worn—or forceps or tongs used, depending on the size of the specimen. Use chemical goggles to protect against splash and fumes.
2. Formalin fumes are irrating to the eyes and throat. Adequate ventilation should be provided in any room where formalin is used

Handling Laboratory Animals

1. Wear heavy rubber or leather gloves when handling laboratory animals.
2. Caution students and visitors about the danger of inserting fingers into an animal cage.
3. "Keep Hands Off" signs should be conspicuous on cages housing biting or otherwise vicious animals.
4. Handle rats, mice, guinea pigs, and other animals gently so as not to excite them.
5. Assure proper and regular cleaning of cages, water bottles and feed containers.

Pollen and Mold Spores

1. In handling flowers, and other pollen-producing plants and mushrooms as well as spore-producing fungi, care should be taken that pollen or spores are not excessively disseminated

throughout the classroom. Many people are allergic to either pollen, mold spores, or to both.

Osmosis Experiments

1. Great care should be exercised in inserting the thistle tube through the rubber stopper. Do not grasp the thistle tube by the bowl; grasp the tubing of the thistle tube near the rubber stopper, wetting it beforehand with water, glycerine, or soap solution. For further protection, the tubing could also be wrapped with cloth.
2. Only fresh materials should be used at all times. Do not use decayed or decaying material. Keep the materials in a refrigerator, if used more than a day, or in formaldehyde.

Extraction of Chlorophyll

1. Only pyrex or other hard glass test tubes should be used.
2. Use an electric heater of the immersion type or a water bath heated by an electric hot plate instead of an open flame or a gas heated water bath for heating the alcohol.
3. Keep open flames away from the alcohol and alcohol vapors. If alcohol ignites in a beaker, cover the beaker with a glass plate to extinguish. If burning alcohol runs over the table, use a fire blanket.

Operation of Pressure Cooker for Sterilizing Bacteria Media

1. Be thoroughly familiar with the proper operation of the pressure cooker. Super-heated steam causes serious burns.
2. Examine safety valve before use and make sure that it is working properly.
3. Keep the pressure below twenty pounds.
4. Pressure must be permitted to return to zero before removing cover. After the pressure has returned to zero, open the stop cock before releasing the clamps.
6. Use approved eye protection when working with the cooker under pressure.

Use of Dissecting Instruments and Dissection Material

1. Care should be taken when handling all dissection instruments; scalpels and needles are dangerous.
2. Always cut down on the specimen to be dissected against a waxed pan or similar holding item.
3. Special care should be taken to avoid cuts and scratches when cleaning equipment.
4. Store dissecting instruments and needles under lock and key.

5. Specimens should be stored and disposed of properly.

Bacterial Experiments

1. Do not use pathogenic organisms.
2. Petri dishes passed around the classroom for inspection of cultures should be bound together with scotch tape.
3. Wire loops used for transferring bacteria cultures should be flamed after each transfer is made.
4. Exposed petri dishes should be soaked in a strong disinfectant (carbolic acid, cresol, lysol, etc.) before being washed.

Human Blood Sampling (Check State and local regulations)

1. If blood typing or other microscopic analysis of fresh human blood is to be conducted in the classroom, obtaining of small drop samples must be done on a voluntary basis. Students should not be required to type their own blood or submit to the procedure by academic coercion. Obtain parental consent notes if your community or school requires them.
2. The danger of spreading infectious diseases such as hepatitis makes it mandatory that sterile techniques be employed.
3. The use of disposable lancets is mandated for this activity. Each lancet should be used only for one person and then carefully and deliberately discarded.
4. The surface of the finger from which blood is withdrawn must be rubbed with sterile absorbent cotton dipped in 70 percent alcohol before removing blood. Use a fresh piece of sterile absorbent cotton dipped in 70 percent alcohol after removing blood.

Insect-Killing Jars

1. Students, either for science projects or for classroom study, often need to be familiar with the proper method for collecting and preserving insects.
2. A safe type of killing jar can be made by using any clean, large, screw-type lid jar (mayonnaise jars are quite acceptable). A tissue is placed in the bottom to serve as an absorber of the killing liquid. Several liquids can be used to provide the lethal fumes; ether, chloroform, or ethyl alcohol. The killing liquid is added to the tissue in the bottom of the jar—about six drops is generally satisfactory. On top of the tissue containing the liquid, a clean tissue is placed to keep the insects dry. The jar must be labeled DANGER, POISONOUS FUMES, DO NOT BREATHE.

3. It is a simple task to recharge the jar with lethal fumes by removing the top tissue and adding a few more drops of the killing liquid. A clean tissue is then replaced and the jar is again ready for use.

4. Alternate method of preparing insect killing jars: 1″-1½″ plaster of paris in bottom of glass jar. Use ethyl acetate (will be absorbed by the plaster of paris). Pour off excess (lasts ten months).

Chemistry

The chemistry laboratory is potentially the most dangerous place in the school. However, this need not constitute a serious threat if the instructor, laboratory assistants, and students have a thorough knowledge of the potential hazards, exercise prudent care and foresight, and use common sense. Accident prevention must be included in the performance of every task, and safety instruction must be an integral part of the overall program of science instruction.

The following statements are offered as suggestions for teachers and students involved in an activity with the material described.

1. In a demonstration experiment, using any flammable liquid such as alcohol, care must be taken that any flame in the room is a safe distance from the volatile liquid.
2. Demonstrations involving explosive or potentially explosive substances must be so arranged as to shield everyone from any danger. Use the safety shield available in the classroom to protect observers and face shield and/or goggles to protect the demonstrators. Size of apparatus and quantities of reagents used in demonstration should be consistent with safety, i.e., preparation of H_2, Cl_2, Br_2, I_2, CO, etc.
3. Observers should be evacuated from seats directly in front of the demonstration table, even if the possibility is remote that injury to them might occur from spattering of chemicals, inhalation of fumes, etc.
4. All persons performing science activities involving hazards to the eyes must wear approved eye protection devices. All persons in dangerous proximity must likewise be equipped.
5. Laboratory aprons should always be worn in the chemistry laboratory.
6. Rubber gloves should be available and used whenever appropriate.
7. All bottles should be properly labeled at all times (see page 41). Reagent bottles should not be recycled—wash and break.
8. Liquids and solids found in unlabeled bottles should be carefully discarded by checking with the department chairperson or school safety officer for proper disposal procedure.

9. Polyethylene squeeze bottles and dropping bottles require special handling to avoid squirting or an excessive number of drops when used. Proper instructions should be provided.
10. Never cap or stopper a bottle containing dry ice or cyrogenic liquids; always plug loosely with cotton.
11. Dry ice can be preserved for short periods of time by wrapping the ice in several layers of newspapers to insulate and reduce the rate of sublimation. Dry ice should be handled with tongs or well insulated gloves to avoid contact with skin and eyes.
12. When pouring liquids, especially caustic or corrosive ones, use a stirring rod to avoid drips and spills.
13. Never pour reagents back into stock bottles. The amount needed should be estimated and the excess properly discarded.
14. Never add water to any concentrated acid, particularly sulfuric acid, because of splashing and heat generation. To dilute any acid, add the concentrated acid to water in small quantities, stirring constantly.
15. Use of a suction bulb or similar device is suggested to fill pipettes and start syphons—never mouth.
16. Where obnoxious or poisonous vapors are produced, the stationary or portable fume hood must be used.
17. When exposed to irritating vapors (SO_2, HCl, Cl_2, NH_3, etc.) avoid possible eye irritation by flushing the eyes with water from an eye-wash fountain. This method is simple and efficacious.
18. Glass wool and steel wool should be handled carefully to avoid breathing or getting splinters into the skin or eyes.
19. Exercise care so that long hose connections between burners and glass outlets are protected from pinching or being pulled away from the outlet.
20. The following general safety chemistry safety precautions always apply:
    - a. Wash hands after each laboratory period.
    - b. Never drink from laboratory glassware.
    - c. Never pipette by mouth!
    - d. Read the label three times before using contents of a reagent bottle.
    - e. Flush the exterior of reagent bottles with water frequently.
    - f. Never taste any chemical unless there are specific instructions to do so.
    - g. Check Bunsen burner hose for security and

leaks before lighting burner.

h. Use beaker tongs to handle hot beakers, not towels or crucible tongs.

i. Test the temperature of questionable beakers, ringstands, wire gauze, or other pieces of apparatus that have been heated by holding the back of the hand close before grasping them.

j. Never point a test tube at yourself or another person, especially when heating. Never look down into a test tube while heating it.

k. Turn off gas valves before leaving station.

Specific Precautions for Experiments

No attempt will be made to describe in detail the procedure for any particular experiment or demonstration. Instead, emphasis will be placed on those practices or procedures or their omission which have cause serious accidents in the past.

In all gas generating experiments, the apparatus assembly should be checked before use to ensure that the delivery system is open so that explosive pressure will not build up. If the gas is collected over water, the delivery tube should be removed from the pneumatic trough (or sink, if using) before the generator stops to prevent water retracting into the generator. Eye protection should be worn.

Preparation of Oxygen

1. By Potassium Chlorate and Manganese Dioxide

a. Using a potassium chlorate/manganese dioxide mixture requires that extreme care be taken to avoid contamination by organic or combustible material. It is strongly recommended that the mixture be prepared in advance and tested by the teacher and possibly conducted as a demonstration. Under no circumstances should powdered carbon be available in the room when conducting this experiment because of its resemblance to manganese dioxide.

b. Potassium chlorate often detonates when ground with mortar and pestle. If the reagent is lumpy, the lumps should be crushed with a large rubber stopper.

2. By Sodium Peroxide

a. If the sodium peroxide method is employed for preparing oxygen, the students should be warned that it is caustic on skin contact and that the residue in the flask is also caustic.

b. Make certain that the sodium peroxide is kept away from paper or other oxidizable inorganic and organic compounds.

Laboratory Preparation of Hydrogen

1. By Metals and Strong Acids
   - a. Check apparatus for leaks at the beginning of the reaction.
   - b. Never ignite hydrogen coming from a generator until you are quite certain that there is no residual air in the generator. One may test for this by taking samples of the evolving gas in a small test tube and bringing these to a Bunsen flame until a non-explosive sample (no "pop") is obtained.
   - c. A towel should always be wrapped around the hydrogen generator when the gas is being generated. The maximum size of generator should be 250 ml.
2. Highly Active Metal and Water
   (Recommended as a teacher demonstration with all wearing eye and face protection.)
   - a. In putting potassium or sodium on water, use very small amounts to minimize dangerous spattering. It is suggested that a medium-sized evaporating dish be used for this experiment, and that a watch glass or glass plate be used to cover it immediately after the metal is put on the water.
   - b. The reaction of sodium on water is safer and should be used in preference to potassium.

Preparation of Sulfur Dioxide

1. Unless good ventilation is available, it is inadvisable to perform this experiment in the laboratory except as a demonstration and then only inside a hood of some temporary design.
2. Students should be cautioned against inhaling the gas, and some provision should be taken to prevent this.

Preparation of Halogens

1. Students should be cautioned about the toxic nature of the halogen vapors. Refer to the teacher's manual of the text to identify specific hazards for each halogen that may be used in the laboratory.
2. It is suggested that chlorine, bromine, and iodine be prepared only by the instructor as a demonstration and only in small quantities.
3. Bromine vapor is poisonous and corrosive to the mucous membrane and the skin; it should be collected under water. Liquid bromine should be prepared only in small quantities. The bromine prepared from this experiment should not be saved. It may be diluted and stored as bromine water, however. If bromine water is kept it should be stored in a glass stoppered bottles sealed with paraffin so that the vapors are not permitted to escape.

4. Hydrofluoric acid is dangerous both in liquid and gaseous form. Soluble fluorides are poisonous. Care should be used in disposing of residue of fluoride salts used in etching

Preparation of Nitrogen and Nitrogen Compounds

1. Nitrogen
   Preparation by heating sodium nitrate and ammonium chloride. This method should never be used as a laboratory experiment. The mixture of sodium nitrate and ammonium chloride is likely to explode if overheated. If performed as a demonstration, make certain that the solution does not boil. If it does, add water.
2. Nitrous Oxide
   Students should not prepare nitrous oxide unless very close supervision can be provided. This gas has strong anesthetic properties.
3. Nitrogen Tri-Iodide—Do not use as a student experiment.
   Nitrogen tri-iodide preparation, because of its susceptibility to shock detonation, should never be prepared by students under any circumstances.

Laboratory Preparation of Rhombic Sulfur

1. By Use of Carbon Disulfide
   a. Carbon disulfide should be used only when there is adequate ventilation and all sources of ignition are removed.
   b. After completing the experiment and before lighting the Bunsen burners to proceed to other experiments, the watch glasses containing the rhombic sulfur should be placed in the fume hood.
   c. Carbon disulfide should be dispensed to students only under strict supervision.
2. By Use of Carbon Tetrachloride
   Carbon tetrachloride, as a solvent for sulfur, is a poor substitute but may be safer than carbon disulfide because it is not flammable. However, its vapors are toxic and extreme care should be taken in its use to avoid inhaling.

Preparation of Esters

The alcohol-acid mixture should be treated in a water bath, never over an open flame. The risk of splattering in the sulfuric acid or igniting the alcohol is too great if heated over the Bunsen burner or any other open flame.

Fractional Distillation of Flammable Liquids

In demonstrating the fractional distillation of gasoline, alcohol, or other flammable liquids, the flask should be heated with a heating mantle or in a sand bath. The receptacle for the collection of distillate should be cooled in an ice bath. Special care should be taken to insure the integrity of the assembly to prevent leakage of flammable vapors.

Spontaneous Combustion

In using phosphorous dissolved in carbon disulfide to demonstrate spontaneous combustion ignition, prepare only enough solution for the demonstration. Do not store the prepared solution. Students should never be allowed to prepare phosphine. The teacher may demonstrate its preparation with greatest care. The generator will explode if air gets in. Spilled or spattered phosphorous may be rendered harmless by treatment with a 2 percent solution of copper sulfate. This treatment should be used before attempting to pick up white phosphorous particles from the skin.

Thermite Demonstrations

Before performing a thermite demonstration, the first several rows of seats should be vacated so that there are no students within ten feet of the reaction. Observers should be wearing appropriate eye protection. Place a bucket of water with the bottom covered with sand under the ignition cup. Be very careful in approaching a mixture that has apparently failed to ignite; the mixture may flare up suddenly. Some teachers find it a refreshing diversion and a reduction of the fire hazard to perform this demonstration outside, building design and weather permitting. Always wear a full face shield and appropriate fire resistant clothing.

Electricity

Since the use of electricity in science laboratories is universal and the potential for electric shock is always present, it is important that basic safety precautions be taken. Electrocution can be caused by any voltage that you came in contact with. It is the amount of current which flows through the body that determines the effect on the body—not the amount of the voltage.

Any amount of current over ten milliamps (0.01 amp) is capable of producing a severe shock and any current above 200 milliamps (0.2 amp) is absolutely fatal. Since the voltage at any one place is usually fixed, such as 110 volts, the amperage that passes through the body is basically determined by the resistance of the human body, as follows:

$$\text{Amperage in the body (amps)} = \frac{\text{Voltage}}{\text{Resistance of body (ohms)}}$$

As the resistance of the human body decrease, the amount of current passing through it will necessarily increase.

The resistance of the human body to electricity is relatively small, except for the skin. Even the resistance of the skin, however, can become quite low under certain conditions. When wet, skin resistance can be reduced from a level of 500,000 ohms to only 1,000 ohms, greatly increasing the chance for a severe shock. Even moisture such as perspiration is a sufficient wetting agent. Thus, to reduce the potential for injury when working with 110-volt lines or other high voltages, the two basic safety precautions are:

1. Do not allow the body to become the path for electricity.
2. Make conditions such that even if the body does become a path for electricity, by accident, the amperage will not be dangerously high.

The following statements are offered as suggestions for the teacher and/or student who is involved in an activity using electricity.

1. Handle all electrical circuits with dry hands. Electrical equipment should only be used while standing on non-metallic floors, rubber mats, or approved carpeting.

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2. All repair work done on electrical equipment should be done by a competent person after the power has been disconnected or shut off.
3. Do not use extension cords.
4. Equipment should be tested for electrical leakage. Any equipment that produces a "tingle" should be removed from service and promptly repaired.
5. It is good practice to use only tools and equipment with nonconducting handles when working on electrical devices, even though the power is shut off.
6. Always treat electrical devices as if they were alive.
7. All electrical contacts and conductors should be enclosed to prevent accidental contact and shock.
8. Do not touch another person's equipment unless told to do so.
9. Do not store highly flammable liquids near electrical equipment because vapor can be ignited by an arc, spark, etc.
10. All electrical appliances and equipment should show listing and approval by Underwriter's Laboratories, Inc., or other nationally recognized testing laboratory.
11. All electrical appliances and equipment should be properly grounded—not to a water pipe. Electrical power tools should be grounded unless approved as "double insulated."
12. All electrical services should be grounded by a certified person.
13. In removing an electrical plug from its outlet, pull the plug, not the electric cord. Broken plugs should be replaced immediately.
14. When inserting an electrical plug, hold the plug so that any flashbacks due to a possible short circuit will not burn the palm of the hand.
15. Switches, fuses, circuit breakers and other control devices should be identified so that their open and closed positions are quickly recognized and the circuits that they control can be easily determined.
16. There should be one master switch that is readily available in the room that can cut off all electricity to all stations.
17. Exposed live electrical switches on the front panels of laboratory and preparation room switchboards should not be allowed.
18. Connections should not be made to electric light sockets for the purpose of operating electrical appliances, or for electric extensions or portable lamps.
19. Students should avoid bringing both hands into contact with "live" sections of the circuit.
20. In wiring an electrical circuit, make the "live"

plug-in or turn-on switch connection the last act in assembling and the first act in disassembling. The teacher should check the student-constructed circuit prior to allowing the flow of electricity to begin .

21. If a current-carrying wire is used near any metal object it must be permanently protected with an insulating cover to avoid possible contact. General care should be observed to see that live wires do not contact metallic objects.
22. Multiple plugs should not be used in electrical wall outlets. Semi-permanent electrical connections should not be made to wall outlets. Under no circumstances should a motor requiring a starting current of more than 1500 watts be connected to a wall outlet. Recepticals for heavy current loads can be installed by an electrician if necessary.
23. Students should be instructed never to "short circuit" dry cells or storage batteries. High temperatures developed in the connecting wires can cause bad burns.
24. Care should be observed in the handling of a storage battery. It is a source of danger in spite of its low voltage because of the acid it contains and because of the very high current which may be drawn from it on a short circuit. Charging of storage batteries must be done with great care and only in a well-ventilated space.
25. Never grasp any electrical device which has just been used. Most electrical devices are hot after use and serious burns may result if the degree of heat is not ascertained before it is grasped.
26. Induction coils should be clearly marked for the low voltage and high voltage connections in order to avoid the possibility of shocks.
27. When charging any type of capacitor, ensure that the rated capacity is not exceeded. In a circuit which contains a fluctuating D.C. voltage, electrolytic tape capacitors which are polarized (±) can be used. When connecting this type capacitor to points in a circuit, exercise extreme caution to make sure that the proper polarity rules are being followed—negative to negative and positive to positive. If the capacitor is connected backwards, an explosion could result.
28. Electric current used in the laboratory should be sent through a protecting limiting load resistance of a circuit breaker so that no more than the desired amount of current will flow under any circumstances.
29. When circuit breakers are not provided, electric lines to students' tables should be protected by enclosed fuses only.

Electronic Equipment

In the handling of electronic equipment, the following precautions should be observed.

1. Keep all electronic equipment in top condition—inspect connections, cords and plugs. Damaged cords and plugs should be replaced immediately. Cracked insulation on cords also indicates the need for replacement.
2. Power disconnect tags should be used whenever electronic equipment is taken out of service for repair.
3. Make certain that the current is off and the apparatus has cooled down before putting hands or tools into any electronic equipment.
4. Areas with high voltage equipment should be clearly marked and restricted to authorized personnel only.
5. Be sure that there is a "bleeder" (high resistance) across the output of a power supply; otherwise a severe shock from the charged condenser may result.
6. In handling the so-called transformerless type of radio, where the tubes are series connected and the set works directly from the line, caution must be observed to prevent any grounded metallic object from coming in contact with the metallic chassis.
7. In experimentation with a standard transformer radio, students must be cautioned on the handling of "B" voltages. The high voltage secondary is in the order of 600 volts A.C., and the rectified "B" voltage is about 300 volts D.C. Severe burns and shock can result from contact.
8. In demonstrations or experiments which require the use of large vacuum tubes such as the cathode ray tube, T.V. picture tube, etc., extreme care should be exercised. Implosion of such tubes can send glass flying thirty feet or more.
9. In addition to the dangers of implosion from vacuum tubes, there is always the possibility of harmful radiation. Shielding from possible ultraviolet, infrared, or x-rays should always be made available when certain generators, electron micropscopes, cold cathode discharge

tubes, etc., are used for demonstrations.

10. Before disposing of a vacuum tube, cover it completely with a heavy canvas cloth and then break it by striking the rear of the tube with a hammer. The broken tube should then be placed in the special container designated for the disposal of broken glass.
11. Microwave equipment, such as microwave optical apparatus, which is available for high school usage is designed with a power density sufficiently low to minimize any possible hazards. Carefully read the manufacturer's specifications for the equipment, which should list all data, including the power density of the apparatus.

Safety With Animals

Students are naturally attracted to animals and respond to them individually as pets. However, every animal is a potential threat to a student or teacher who handles it. This is particularly true of mammals.

One preventive measure practiced by many schools is a policy which requires permission of the principal before any warm-blooded animals (including birds) can be kept in a classroom, and that once this is done, the animals cannot be kept there for more than fourteen days. This should be supplemented with the requirement that all wild animals should be held in isolation outside the classroom for at least a week before being brought in. All animals should be purchased from a reputable supply house and the presence of wild animals in the classroom should be avoided.

Potential danger exists with animals brought in by students who find birds, raccoons, squirrels, oppossums, mice and others that have been struck by a car or are otherwise too weak to escape a child's enthusiasm. Animal weaknesses may be due to an undetected illness. Animal diseases may include ringworm, rabies, rabbit fever, and a host of others that can be carried by vectors parasitizing the weakened animal. Fleas may carry worms which can be inhaled or swallowed by students. These may result in fatalities not associated with the prior handling of animals, including dogs and cats. Ticks and mites can fall into the clothing of a student and later attach themselves behind the student's ear or to other creases and folds of the body.

If mice, rabbits, gerbils, and guinea pigs, common animals found in laboratories, are not fed properly or have been deprived of water, as may happen over a weekend, they may scratch or bite the student handling them. Finding some of the remains of one of the animals is an indication of water deprivation and is a threatening possibility. Extreme care must be taken in working with such animals in the immediate future, including watering them. Any student bitten by any animal should be attended to in accordance with recommended procedure immediately, with a report filed as to the source of the wound. The animal should NOT BE DESTROYED, but should be kept especially safe until examined by authorities.

After an animal has been kept in a cage, the cage should be thoroughly cleaned, using strong detergents and germicides. If possible, the cage should be boiled or scrubbed with boiling water. It is quite possible that the first animal may leave behind an infectious organism which the newly introduced animal can transmit to the teacher or students.

Danger Signs

1. Unusual odor emanating from the cage.
2. Animal is sluggish, unresponsive.
3. Constant or unusual bickering or fighting between inmates. (Not to be confused with peck order behavior.)
4. Loss of appetite.
5. Hair, eyes, or skin change color with an unhealthy pallor.
6. Unusual discharges from body openings.
7. Fellow inmates dead or body remnants in cage.
8. Frequent sneezing.

There should be no question about a student's role in caring for the animals in a laboratory. A specific routine should be posted with emphasis on scrubbing the hands after handling the cage or animals. Providing proper care and regularly feeding and providing fresh water will lessen the chance of having sick animals. This will considerably help to control diseases.

A laboratory animal is NOT A PET. If it is treated as a pet, then it serves little purpose as a laboratory animal and can create a psychological situation that is unwarranted. If the animals have been used as laboratory objects, they are not used to being handled often and may bite or scratch unintentionally. Before a vertebrate is used in any type of experiment, policy and regulations should be checked out at the school, county and state level. Any animal that has been part of an experiment, whether it be one relating to behavior or a response to some chemical agent, usually undergoes a change which will alter its normal behavior. This is especially true of old or introduced wild animals. It is unwise to:

1. Handle gravid or nursing females.
2. Try to "cure" an animal brought in by a student.
3. Mend a suspected "broken bone" in a wild animal.
4. Disect an animal found injured along a highway.
5. Pet and cuddle wild or laboratory animals.

Before a student is allowed to work with animals, there should be instruction in the proper methods of handling and carrying. Leather gloves should be worn when working with live animals.

With the increasing interest in marine biology, many students have been bringing in a variety of fish, sea urchins, mollusks, etc., to class. Although these animals ordinarily do not attack the collector directly, each should be handled with care. An octopus can inflict a sharp wound. Spines of fishes and urchins can cause very painful infections due to the foreign proteins carried into the body during penetration. Even living mollusks can inflict a dangerous wound. Only incomplete records prevent knowing how many people have suffered from wounds acquired while handling marine organisms. This includes allergic responses to such things as seemingly harmless egg cases of whelks and the clusters of algae that may hide many marine worms. The symptoms are usually identified by itching, swelling of the hands, and a slight headache.

The following is a partial list of organisms known to cause harmful reactions when handled carelessly.

Ants
Bedbugs
Bees
Black Widow Spider
Blister Beetles
Brown Recluse Spider
Centipedes
Chiggers
Clams*
Copperhead Snake
Coral Snake
Cottonmouth Snake
Fleas
Gnats
Ioa Caterpillar
Jelly Fish
Millipede
Mosquitoes
Mussels*
Nettling Caterpillar (Slug Caterpillar)
Oysters*
Pussmoth (Saddleback Caterpillar)
Potato Beetles
Rattlesnake
Ticks (Dermacenter and Ixodidae)
Wasps
Yellow Jackets

Fishes known to cause poisoning. This usually depends on where fish has been caught and its diet.

Barracuda
Butterfly fish
Goat fish
Moon fish
Moray eel
Parrot fish
Perch
Pompano
Porcupine fish
Puffers
Sea Bass
Snapper
Sting Rays
Surgeon fish
Triggerfish
Wrasse

* When living in polluted water or feeding on certain dinoflagellates.

Before performing any experiment involving animals, teachers should check the local and state regulations. Some states require certification before teachers are permitted to experiment with animals. The Society for the Prevention of Cruelty to Animals and/or the Humane Society should also be consulted. The following guidelines are adapted from the U.S. Humane Society.

1. In biological procedures involving living organisms, species such as plants, bacteria, fungi, protozoa, worms, snails, or insects should be used wherever possible. Their wide variety and ready availability in large number, the simplicity of their maintenance and subsequent disposal, makes them especially suitable for student work. In mammalian studies, nonhazardous human experiments are often educationally preferable to those using species such as gerbils, guinea pigs, or mice.
2. No procedure shall be performed on any warmblooded animal that might cause it pain, suffering, or discomfort or otherwise interfere with its normal health. Warmblooded animals include man, other mammals such as gerbils, guinea pigs, mice, rabbits, hamsters, and rats. It also includes birds such as chickens, quail, and pigeons. This means that a student shall do unto warmblooded animals only what he can do himself without pain or hazard to health.
3. No surgery shall be performed on any living vertebrate animal (mammal, bird, reptile, or amphibian).
4. No lesson or experiment shall be performed on a vertebrate animal that employs microorganisms which can cause disease in man or animal, ionizing radiation, cancer-producing agents, chemicals at toxic levels, drugs that produce pain or deformity, extremes of temperatures, electric or other shock, excessive noise, noxious fumes, exercise to exhaustion, overcrowding, or other distressing stimuli.
5. Animal observations must be directly supervised by a competent science teacher who shall approve the plan before the student starts work. Students must have the necessary comprehension and qualifications for the work contemplated. The supervisor shall oversee all experimental procedures, shall be responsible for their nonhazardous nature, and shall personally inspect experimental animals during the course of the study, to ensure that their health and comfort are fully sustained.
6. Vertebrate studies shall be conducted only in

locations where proper supervision is available; either in a school or in an institution of research or higher education. No vertebrate animal studies shall be conducted at a home (other than observations of normal behavior of pet animals such as dogs and cats).

7. In vertebrate studies, palatable food shall be provided in sufficient quantity to maintain normal growth. Diets deficient in essential foods are prohibited. Food shall not be withdrawn for periods longer than twelve hours. Clean drinking water shall be available at all times (and shall not be replaced by alcohol or drugs).
8. Birds' eggs subjected to experimental manipulations shall not be allowed to hatch; such embryos shall be killed humanely no later than the nineteenth day of incubation. If normal egg embryos are to be hatched, satisfactory arrangements must be made for the humane disposal of chicks.
9. In the rare instances when killing of a vertebrate animal is deemed necessary, it shall be performed in an approved humane (rapid and painless) manner by an adult experienced in these techniques.
10. Projects involving vertebrate animals will normally be restricted to measuring and studying normal physiological functions such as normal growth, activity cycles, metabolism, blood circulation, learning processes, normal behavior, reproduction, communication or isolated organ techniques. None of these studies requires infliction of pain.
11. The comfort of the animal observed shall receive first consideration. The animal shall be housed in appropriate spacious, comfortable, sanitary quarters. Adequate provision shall be made for its care at all times, including weekend and vacation periods. The animal shall be handled gently and humanely at all times.
12. Respect for life shall be accorded to all animals, creatures, and organisms that are kept for educational purposes.

References: "HSUS Guiding Principles for Use of Animals in Elementary and Secondary Education," Humane Society of the United States, 2100 L Street, N.W., Washington, D.C. 20037, free.

"How to Care for Living Things in the Classroom," Grace K. Pratt-Butler, National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C. 20009, $1.00.

Safety With Plants

Poison ivy, poison oak, and poison sumac are well advertised outdoor dangers, but growing around them in woods, fields, backyards, and even in the home are some 700 other species of plants known to cause death or illness. Teachers should familiarize themselves with the most common poisonous plants typically found in their area.

Since ALL plants have not been thoroughly researched for their toxicity, a few common rules are:

1. Never eat unknown berries, seeds, fruits, or other plant parts.
2. Never rub any sap or fruit juice into or on the skin or open wound.
3. Never inhale or expose your skin or eyes to the smoke of any burning plant or plant parts.
4. Never pick any strange wildflowers or cultivated plants unknown to you.
5. Never eat food after handling plants without first scrubbing your hands.

The reason for these "Never" precautions is that any part of a plant can be relatively toxic.

Since the parents of many students have gardens and use some dangerous insecticides, instructions should be given in the danger during handling or use. Students should be instructed that when working with plants that have been sprayed by insecticides they must take the same precautions that they would when working with any hazardous chemical substance.

Teachers should become suspicious and act very quickly if they notice any of their students exhibiting any of the following signs of plant poisoning—constriction of pupils, increase in nasal and salivary secretions, sweating, gastrointestinal disturbance, tightness in the chest, muscle tremor, blueness around the lips and under the fingernails, or indications of convulsions. First Aid measures may have to be taken and the Poison Control Center alerted.

The following is a list developed by the National Safety Council of plants that could pose a threat to the safety of the student and teacher alike. Please note that the list is far from exhaustive and that any plants peculiar to your area should be added.

House Plants

Hyacinth, Narcissus, Daffodil (Bulbs)
Nausea, vomiting, diarrhea. May be fatal.

Oleander (Leaves, branches)
Extremely poisonous. Affects the heart, produces severe digestive upset, and has caused death.

Diffenbachia, Elephant's-ear (All parts)
Intense burning and irritation of the mouth and tongue. Death can occur if base of the tongue swells enough to block the air passage of the throat.

Rosary pea, Castor bean (Seeds)
Fatal. A single rosary pea seed has caused death. One or two castor bean seeds are near the lethal dose for adults.

Poinsettia (Leaf)
One leaf can kill a child.

Mistletoe (Berries)
Can be fatal

Flower Garden Plants

Larkspur (Young plant, seeds)
Digestive upset, nervous excitement, depression. May be fatal.

Monkshood (Fleshy roots)
Digestive upset and nervous excitement.

Autumn crocus, Star-of-Bethlehem (Bulbs)
Vomiting and nervous excitement.

Lily of the valley (Leaves, flowers)
Irregular pulse, usually accompanied by digestive upset and mental confusion.

Iris (Underground stems)
Severe, but not usually serious, digestive upset.

Foxglove (Leaves)
One of the sources of the drug digitalis, used to stimulate the heart. In large amounts, the active principles cause dangerously irregular pulse, usually digestive upset and mental confusion. May be fatal.

Bleeding heart, Dutchman's breeches (Foliage, roots)
May be poisonous in large amounts.

Rhubarb (Leaf blade)
Fatal. Large amounts of raw or cooked leaves can cause convulsions, coma, followed rapidly by death.

Ornamental Plants

Daphne (Berries)
Fatal. A few berries can kill a child.

Wisteria (Seeds, pods)
Mild to severe digestive upset. Many children are poisoned by this plant.

Ornamental Plants (cont'd)

Golden chain (Bean-like capsules in which seeds are suspended)

Severe poisoning. Excitement, staggering, convulsions, and coma. May be fatal.

Laurel, Rhododendron, Azalea (All parts)

Fatal. Produces nausea and vomiting, depression, difficult breathing, prostration, and coma.

Jessamine (Berries)

Fatal. Digestive disturbance and nervous symptoms.

Lantana camera—red sage (Green berries)

Fatal. Affects lungs, kidneys, heart and nervous system. Grows in the southern U.S. and in moderate climates.

Yew (Berries, foliage)

Fatal. Foliage more toxic than berries. Death is usually sudden without warning symptoms.

Trees and Shrubs

Wild and cultivated cherries (Twigs, foliage)

Fatal. Contains a compound that releases cyanide when eaten. Gasping, excitement, and prostration are common symptoms that often appear within minutes.

Oaks (Foliage, acorns)

Affects kidneys gradually. Symptoms appear only after several days or weeks. Takes a large amount for poisoning. Children should not be allowed to chew on acorns.

Elderberry (Shoots, leaves, bark)

Children have been poisoned by using pieces of the pithy stems for blowguns. Nausea and digestive upset.

Black locust (Bark, sprouts, foliage)

Children have suffered nausea, weakness, and depression after chewing the bark and seeds.

Wooded Area Plants

Jack-in-the-pulpit (All parts, especially roots)

Like diffenbachia, contains small needle-like crystals of calcium oxalate that cause intense irritation and burning of the mouth and tongue.

Moonseed (Berries)

Blue, purple color, resembling wild grapes. Contains a single seed. (True wild grapes contain several small seeds.) May be fatal.

May apple (Apple, foliage, roots)

Contains at least sixteen active toxic principles, primarily in the roots. Children often eat the apple with no ill effects, but several apples may cause diarrhea.

Swamp or Moist Area Plants

Water hemlock (All parts)

Irritant juices may severely injure the digestive system.

Swamp or Moist Area Plants (cont'd)

Nightshade (All parts, especially the unripe berry)

Fatal. Intense digestive disturbances and nervous symptoms.

Poison hemlock (All parts)

Fatal. Resembles a large wild carrot.

Jimson weed—thorn apple (All parts)

Abnormal thirst, distorted sight, delirium, incoherence, and coma. Common cause of poisoning. Has proved fatal.

Reference: *Human Poisoning from Native and Cultivated Plants,* James W. Hardin and Jay M. Arena, Duke University Press, Durham, North Carolina, 1977. The 194-page book contains photographs, black/white and color, and illustrations. Scientific and common names are given along with description, occurrence, poisoning, and guide to the physician.

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Lasers

Science teachers should be aware of the inherent dangers which accompany the operation of lasers. Their use in demonstrations or in research activities must be preceded by orientation to the potential hazards. The knowledge that a hazard exists should be combined with prudent working practices. To assist you in a safety program, the following safety precautions are recommended to minimize the risk of injury to students and other observers.

Eye Hazards

Perhaps the greatest danger is accidently focusing the laser beam on the eye. Even low power beams may burn the retinal area, producing a blind spot. If the retinal area irradiated is the macula, its fovea (area of extremely fine vision) or the optic nerve, then severe permanent visual damage may result.

Skin Hazards

The effects here are basically those of burns. Lighter skin with little melanin pigment is affected to a lesser degree, whereas skin with high melanin content—overall or in spots, such as moles—may be burned severely.

The following is a list of precautions when using lasers.

1. Check with your local school district to see if the use of lasers is approved for secondary school use.
2. Avoid direct viewing of the laser beam regardless of any power output, even when protective goggles are used. Aim the beam indirectly and isolate the operator completely from the head of the laser, whenever possible.
3. Protect everyone against reflective beams by using non-reflective, fire-resistant surfaces as a background for the direct beam. Viewing a reflective should also be avoided. Coat or paint the firing area to absorb scattered and reflective radiation. Remove all reflective objects from the anticipated beam path. All optical components should be rigidly fixed with respect to their position relative to the laser.
4. Keep the working area well lighted at all times when the laser system is in use. This will tend to keep the pupil of the eye relatively constricted and reduces the light impinging on the

retina accidently.

5. Prepare and test demonstrations without others present. The possibility of an unexpected reflection should always be considered.
6. Do not use high-powered laser systems. The maximum power output must be stated on the laser. Rarely does school demonstration require a power over 0.5 milliwatt for a Helium-Neon laser.
7. Block the beam when it is not needed. Add a shutter or cap which can be operated to allow the beam to radiate ONLY when necessary for measurements or observations.
8. Affix expanding lens rigidly to the laser. When the laser is used to illuminate large surfaces, such as in the viewing of holograms, beam expanding lenses should be rigidly affixed to the laser.
9. The laser should be equipped with a key switch in the primary power circuit, rather than the more commonly used toggle-type switch. Key switches are available from electronic supply stores for a relatively small charge.
10. Do not leave an operable laser accessible and unattended!
11. The optical power used should be reduced to the minimum necessary to accomplish the classroom objective. Neutral density filters or colored plastic can be used effectively to reduce radiated optical power.
12. Isolate all laser operations as far as practical, to reduce the number of persons who come in contact with the laser beam.
13. Provide and use designated wavelength protective eye devices. Eye protection with shatter-resistant goggles is essential for some types of laser systems—no one type of goggles offers protection for all wavelengths. Do not operate unless the proper goggles are available and are used.
14. Insure protection against electrical shock from both high and low voltage equipment, by avoiding accidental activation of stored charge.
15. Instruct all students about the dangerous features and safe use of the laser system.

Radioactive Materials

The properties of radioactive materials are such that they have numerous applications in scientific research, medicine, and industry. It is anticipated that these applications will not only continue, but increase dramatically in number and in kind. The science program of some schools may wish to provide students with an opportunity to investigate radiological theory, use limited quantities of radioactive materials, and to develop techniques and skills in handling such materials safely.

The use of radioactive isotopes is regulated by the Federal Government and by laws and regulations of the states. Teachers or other prospective users of radioactive isotopes should obtain the respective state publication "Radiation Control Regulations" and should be aware that some school districts prohibit their use. Teachers considering using radioactive materials should be fully aware of all the potential hazards involved and the limits on the use of such materials with minors, students under the age of eighteen.

It is expected that teachers will confine their use of radioactive materials to quantities of such low hazard potential as may be obtained. Use of such small quantities of radioactive materials is automatically granted by the Federal Government and is referred to as a "general license."

Quantities of radioactive materials are available which generally conform to the restrictions of the general license. Example of maximum unit quantities are: Carbon-14, uc (microcuries); Phosphorus-32, 10 uc; Iodine-131, 10 uc. Under a general license, a user may possess at any time no more than ten such unit quantities of material. For example, a user may possess at one time 500 uc of Carbon-14 in ten separate sources, or 450 uc of Carbon-14 (in nine units) and ten uc of Iodine-131. Users may possess fractional scheduled quantities of as many isotopes as needed to the extent that the total of all quantities does not exceed ten scheduled quantities. The degree of decay of each sample may be considered when totaling the quantities in possession. Individual teachers should coordinate their purchase through their departments and school principal so that the school as a unit does not exceed these quantities. Although these quantities of material may be purchased without need for a specific license, the user is not exempt from adhering to the regulations pertaining to their use.

The nature of radioactivity is such that even though very small potential hazard quantities are used, carefully planned and executed safety precautions must be accomplished. Each teacher who receives radioactive materials must assume responsibility for supervising their use and/or safe storage, observing the following safety practices.

1. **Records.** The importance of keeping complete, permanent records of all events associated with radioactive materials cannot be overemphasized. Such recordkeeping will serve as exemplary procedures for instructing students as well as provide significant permanent information. A bound notebook may serve as a logbook in which is recorded the following kinds of information:
    - a. Kinds and amounts of radioactive materials possessed, the date of receipt, the use made of them, the name of the user, and the method and date of their disposal.
    - b. Class rosters—when students actively participate in investigations relating to ionizing radiation. These records should clearly indicate the presence or absence of the student on a given day, and, if present, the amount of exposure to radiation.
    - c. Details of unusual incidents which may occur, such as a spill.
    - d. Monitoring records.
2. **Monitoring.** The laboratory equipment should be monitored to ascertain the absence of contamination. This should be done before and after each experiment and at regular intervals. Records of the laboratory monitoring should be maintained in the logbook. Clothing and hands of the personnel should be included in the monitoring. Dosimeters or film badges should be used to establish the extent of exposure of personnel, and the data obtained entered in the logbook.
3. **Signs.** On days when radioactive isotopes will be used, a large poster or sign containing the radiation symbol should occupy a prominent position where each student will see it upon entering the classroom. The symbol should be covered or removed when students will not be exposed to radiation. This will aid in keeping students alert to potential danger. All of the students in the school should be informed of the significance of the radiation symbol. Visitors must not be allowed in the laboratory except by special arrangements.
4. **Controls.** All radioactive materials should be

kept under lock and key when the responsible individual is not in the laboratory. Students should never be allowed to remain unsupervised in the laboratory with radioactive materials, not even radioactive waste solutions.

5. **Labeling.** All containers of radioactive materials should be clearly labeled. The label should contain the date of assay and the kind and quantity of radioactive material, and should carry the standard yellow and magenta radioactivity symbol. Adhesive-backed labels with the proper legend and color are available commercially. Glassware and equipment which retains a relatively high activity should be labeled and segregated from general use. All apparatus, once it has been used with radioactive materials, is often retained for that exclusive use. Clearly label the cages/containers of all experimental animals/plants.

6. **Storage.** Radioactive sources, whether exempt or not, shall be stored when not in use in a suitable location with means to prevent unauthorized use. Adequate shielding should be provided. A responsible person should be designated as source custodian. This individual should keep a continuous record of each source, its location, its original assay with date, user, and final disposition. Containers of radioactive solutions should be kept closed except when in actual use.

7. **Protective Equipment.** Preventing contamination is easier than decontaminating furniture and equipment. Avoid spills by clamping containers or keeping them in secondary containers such as a beaker or a hole drilled in a block of wood which is not easily upset. Confine spills by working in trays lined with absorbent material having water-repellent backing. Disposable diapers, diaper paper, or similar set-up may protect the working surface from contamination. Always use a forceps or tongs to handle radioactive materials—*never pipette by mouth*. If inhalation of vapor or powders is possible, use the fume hood or gloved box.

8. **Protective Clothing.** Skin and personal clothing may be protected from contamination by wearing gloves or plastic disposable gloves and laboratory aprons or coats. Ingestion of radioactive materials is the greatest danger involved in handling generally licensed materials.

9. **Personal Safeguards.** Never eat, drink, smoke, chew gum, or use cosmetics in a room where radioactive materials are being used. Washing hands with soft brush, soap, and water must be

standard procedure following the handling of radioactive material even though gloves are worn.

10. **Maintain Good Housekeeping.** Remove unnecessary equipment from a working area where it might become contaminated. Give immediate attention to cleaning up any contamination.
11. **New Procedures.** Try out all new procedures with "dry runs" not involving the use of radioactive material.
12. **Disposal of Radioactive Waste.** Collect and label all radioactive waste. A specially labeled can lined with a waterproof disposal sack, such as a "step-on" garbage can, should be provided for disposal of radioactive waste. Personal responsibility for disposal should be assumed by the teacher. Soluble materials obtained under a general license can usually be discharged into the sanitary sewer if diluted with large quantities of water. Similar quantities of solid materials (including animal carcasses, organs, and plants) should be incinerated by special arrangements.
13. **Decontamination Procedure.** The problem of decontaminating a particular surface will vary with the amount and kind of contamination. The following procedures should be sufficient for any spill that occurs. When several steps are listed, monitor after the first step and if the contamination is not removed, continue or repeat the decontamination process. The maximum radiation level of a decontaminated area is generally considered to be double background when monitored with a thinwindowed G.M. probe less than an inch from the surface and there is no removable contamination as indicated by a wipe test.

a. *Skin-spot Contamination.* Use a soft brush with soap and water. Repeat if necessary, but do not continue to the extent of damaging the skin.

b. *Clothing.* Wash with detergent and hot water.

c. *Rubber.* Wash first with suds and hot water, then rinse in dilute nitric acid; follow with scouring powder and rinse.

d. *Glassware.* Wash with detergent and hot water, then with a chromic acid cleaning solution if necessary.

e. *Metal.* Wash with detergent and hot water. If necessary, wash in dilute HNO_3 or ten percent sodium citrate solution.

f. *Linoleum.* Wash with detergent and hot water. Wash with kerosene, or ammonium citrate solution if required.

g. *Ceramic Tile.* Wash with detergent and hot water, then with mineral acid, trisodium phosphate or ammonium citrate.

h. *Painted Surfaces.* Wash with detergent and hot water. Wash with ten percent HCl if contamination remains.

i. *Concrete.* Wash with detergent and hot water. Wash with thirty-two percent HCl if necessary.

j. *Wood.* Wash with detergent and hot water. Plane surface if contaminant is a long-lived isotope.

k. *Laboratory Taps and Drains.* Flush with large volume of water. Scour with scouring powder or rust remover.

14. A source used to produce radiation field should be sealed in a suitable container or prepared in a form providing equivalent protection from mechanical disruption.

15. If possible, the radioactive material in the source should be of low toxicity and in such a form as to minimize dispersion and ingestion in case the container should be broken. The quantity of radioactive substances necessary for a specific purpose should be chosen as small as possible.

16. Sealed sources or appropriate containers should be regularly checked for contamination or leakage.

17. Sources should be handled in a way that the radiation dose to the student is reduced to a minimum by such methods as shielding, distance, and limited working time.

18. Source should not be touched by hands. Appropriate tools should be used; for instance, long handled, lightweight forceps, with a firm grip.

19. For beta rays, the protection of eyes, face, and body can be provided by shielding with transparent plates of moderate thickness. Shielding should be as near to the source as possible.

20. The place of storage should be adequately shielded and chosen so as to minimize risk from fire. Records which are kept of all radioactive substances stored should contain clear information on the type of source, activity, and time of removal and return as well as the name of the person responsible for the source during its absence from storage.

21. Containers should open easily.

22. When transporting a radioactive source in the

room, use only the smallest amount necessary. Transportation should be done in shielded and closed containers constructed to prevent accidental release of the source material in case of spill.

23. No one with an open skin below the wrist (protected by a bandage or not) should work with radioactive isotopes.
24. Students should wear lab coats when working with all sources. Rubber gloves also should be worn when working with unsealed sources. Wash gloves before taking them off.
25. The working area should have a linoleum floor and working surface covered with non-absorbent material with disposal covers.
26. When working with gamma radiation, the working surface must be able to support the weight of the necessary shielding.
27. All places and equipment that have been in contact with radioactive materials should be systematically monitored.
28. When working with unsealed sources, the hands, clothing, and particularly shoes should be monitored.
29. Hands should be washed thoroughly before leaving the controlled area.

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Model Rocketry

A few states have enacted statutes defining the types of rockets that can be fired, where this may be done, and in what manner. Some of these statutes define the design, construction, and weight of the rocket as well as the type and amount of propellant materials. If the science teacher should decide to offer a program of model rocketry, it is highly recommended that the laws of the state be observed very carefully. In the event that the state has no statute relating to model rockets, it is suggested that the science teacher obtain a copy of the Connecticut law and use it as a minimum safety standard.

The Federal Aviation Agency has also established regulations concerning the launching of model rockets. These regulations stipulate that model rockets must be operated in a manner that does not create a hazard to persons, property, or other aircraft.

The following safety recommendations for rockets are adapted from the Oakland County, Michigan "Science Safety Series."

1. The gross weight of the rocket, including the engine, should not exceed 16 ounces (453 grams).
2. No more than 4 ounces (113 grams) of propellant materials should be contained in the engine at time of launch.
3. The rocket should be constructed so as to be capable of repeated flights and should contain means for retarding descent to the ground so that it will not be substantially damaged.
4. The rocket flight should not create a hazard to persons and property on the ground.
5. The rocket should be constructed without substantial metal parts.
6. The design and construction should include attached surfaces which will provide aerodynamic stabilizing and restoring forces necessary to maintain a substantially true and predictable flight path.
7. The rocket should not contain any type of explosive or pyrotechnic warhead.
8. The engine should be commercially manufactured so that all of its chemical ingredients of a combustible nature are pre-mixed and ready for use.
9. The force or motive power should be created

by a rearward discharge of gas generated by the combustion, or other operation of the materials contained solely within the device.

10. If the engine is constructed with the use of metal, it should be equipped with a safety release in the event of a rupture of the engine casing.
11. The engine must be so designed and constructed as to be incapable of spontaneous ignition or combustion: in air, water, under pressure, as a result of motion or jarring, when subjected to a temperature of 170 degrees Fahrenheit, or in glycerine.
12. The launch area should contain at least 5,000 square yards, be generally rectangular in shape with no side less than 50 feet in length.
13. Flight areas should not contain or be located adjacent to: a high voltage power line, major highways, multi-story buildings, or other obstacles.
14. At time of launch a device should be used that will restrict the horizontal motion of the rocket until sufficient flight velocity has been attained for a reasonably safe predictable flight.
15. The launching or igniting of the rocket should be conducted by remote electrical means fully under the control of the person launching the rocket.
16. The launching angle should be between 60 degrees to 90 degrees from horizontal.
17. The teacher should inspect each rocket prior to flight and supervise all launchings.
18. All persons in the area of the launch should be warned that a launching is imminent.
19. At time of launch the wind speed should be less than 20 mph and the visibility should be greater than 2,000 feet.
20. Students should not be allowed to tamper with the engine.

Appendix

Carcinogens

Several years ago when the Occupational Safety and Health Administration issued its industry standards, included with a list of substances that cause cancer in humans. To avoid having these compounds on hand in school storerooms, the list was widely circulated throughout the United States and teachers were asked to inspect and remove any of the carcinogens from their school supply.

The following should not be purchased, used, or stored in the schools:

4-Nitrobiphenyl (4-NBP)
Alpha-Naphthylamine (1-NA)
4, 4′-Methylene bis (2-chloroaniline) (MOCA)
Methyl chloromethyl ether (CMME)
3, 3′ Dichlorobenzidine (and its salts)
Bis chloromethyl ether (BCME)
Beta-Naphthylamine (2-NA)
Benzidine
4-Aminodiphenyl
Ethyleneimine (EL)
Beta-Propiolactone (BPL)
2-Acetylaminofluorene
4-Dimethylaminoazobenzene (DAB)
N-N′ trosodimethylamine (DMN)
Vinyl chloride
Asbestos

Be aware that many of these substances are known by a variety of names. A list of the carcinogens and their synonyms was published in the September 1976 *Journal of College Science Teaching*. Reprints of the list are available from your local chapter of the American Lung Association (or write, American Lung Association, 1740 Broadway, New York, N.Y. 10019).

If any of the substances listed above are on hand in the school, the teacher should immediately contact the department chairperson, principal, and district safety officer to immediately take steps for the removal of these chemicals. If a district safety officer is not available to advise steps to be taken for the removal of these chemicals, it is recommended that one of the area or regional offices of OSHA, NIOSH, or EPA be contacted to determine where the cancer causing substances may be taken for proper disposal. Most populated areas in the United States have locations where hazardous chemicals may be disposed of by personnel in charge. Local chemical supply houses usually know the location and agency charged with that responsibility in the event that contact cannot be made with a representative of one of the above agencies.

A course cooperatively developed by the Council of State Science Supervisors and the National Institute for Occupational Safety and Health is available to all secondary science teachers. This course is designed to involve the participants with some of the legal concerns as well as instructional procedures for developing an individual science teacher safety program.

Handling glassware, chemicals, and many of the instruments found in today's modern school science laboratories enables the training leaders and teachers to discuss many techniques not presented in the course manual. A laboratory safety checklist, the use of safety equipment, and reporting incidents are fundamental to this safety program. Many school inventories indicate the storage area contains several unwanted and unusable chemical reagents and equipment. The how and where to dispose of these materials is a very valuable service for each science teacher.

The course requires a minimum of sixteen hours and is available through the state science supervisor or other personnel in the state department of education. Many states provide each participant who completes the course with one unit of continuing education credit or credit toward renewing the teacher certificate. CS3 and NIOSH will give a certificate of completion suitable for framing and displaying in the laboratory.

For further information, write to your state department of education or the Council of State Science Supervisors, c/o Mr. Franklin D. Kizer, P.O. Box 6Q, Richmond, Virginia 23216.

(check one)
☐ School Jurisdictional
☐ Non-School Jurisdictional

RECOMMENDED
STANDARD STUDENT ACCIDENT REPORT

(check one)
Recordable ☐
Reportable Only ☐

School District:
City, State:

General

1. Name
2. Address
3. School
4. Sex Male ☐ Female ☐
5. Age
6. Grade/Special Program
7. Time Accident Occurred Date: Day of Week: Exact Time: AM ☐ PM ☐

Injury

8. Nature of Injury
9. Part of Body Injured
10. Degree of Injury (check one) Death ☐ Permanent ☐ Temporary (lost time) ☐ Non-Disabling (no lost time) ☐
11. Days Lost From School: From Activities Other Than School: Total:
12. Cause of Injury
13. Accident Jurisdiction (check one) School: Grounds ☐ Building ☐ To and From ☐ Other Activities Not on School Property ☐ Non-School: Home ☐ Other ☐
14. Location of Accident (be specific)
15. Activity of Person (be specific)
16. Status of Activity
17. Supervision (if yes, give title & name of supervisor) Yes ☐ No ☐

Accident

18. Agency Involved

19. Unsafe Act

20. Unsafe Mechanical/Physical Condition

21. Unsafe Personal Factor

22. Corrective Action Taken or Recommended

23. Property Damage
School $ Non-School $ Total $

24. Description (Give a word picture of the accident, explaining who, what, when, why and how)

Signature

25. Date of Report

26. Report Prepared by (signature & title)

27. Principal's Signature

This form is recommended for securing data for accident prevention and safety education. School districts may reproduce this form adding space for optional data. Reference: *Student Accident Reporting Guidebook*, National Safety Council, 425 N. Michigan Avenue, Chicago, Illinois 60611. 1966. 34 pages.

Student Safety Contract

I will:

- Follow all instructions given by the teacher
- Protect eyes, face, hands, and body while conducting class activities
- Carry out good housekeeping practices
- Know the location of first aid and fire fighting equipment
- Conduct myself in a responsible manner at all times in a laboratory situation.

I,______________________________, have read and agree to abide by the safety regulations as set forth above and also any additional printed instructions provided by the teacher and/or district. I further agree to follow all other written and verbal instructions given in class.

Date__________

____

Signature

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